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DMS-DR-2482
NASA-CR 160,816
VOLUME 3 of 3

RESULTS OF TESTS FOR FORCE, MOMENT, PRESSURE AND
AEROELASTIC DATA USING THE 0.030 SCALE PRESSURE
LOADS SPACE SHUTTLE ORBITER MODEL (47-0) IN THE
NASA/ARC 11 FOOT UNITARY PLAN WIND TUNNEL,
(ØA400)

# SPACE SHUTTLE
# AEROTHERMODYNAMIC DATA REPORT

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# PUBLICATION CHANGE

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A change is made to page 53 of the text to replace an improperly cropped
model sketch with the correct sketch.  This change applies to all three
volumes of this data report.

Prepared by:   Liaison  -  S. R. Houlihan
               Operations -C. R. Edwards

Approved: _J. Y. Bly_____   Concurrence: _____
          J. L. Glynn, Manager                  N. D. Kemp, Manager
          Data Operations                       Data Management Services

PAGE   1   OF   1

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LOADS SPACE SHUTTLE ORBITER MODEL (47-0) IN THE
NASA/ARC 11 FOOT UNITARY PLAN WIND TUNNEL,
(ØA400)

by

R. H. Spangler
Rockwell International
STS D&P Division

by

Data Management Services
Chrysler Huntsville Electronics Division /Slidell Engineering Office
New Orleans, La.   70189

for

Engineering Analysis Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

Wind Tunnel Test Specifics:

| | |
|---|---|
| Test Number: | ARC 427-1-11 ARC 427-2-11 |
| NASA Series Number: | OA400 |
| Model Number: | 47-0 |
| Test Dates: | 4/23/80 to 5/2/80 |
| Occupancy Hours: | 120 |

Facility Coordinator:

J. J. Brownson
Mail Stop 227-5
Ames Research Center
Moffett Field, CA 94035
Phone: (415) 965-6262

Project Engineers:

R. Spangler & A. Kanevsky
Rockwell International
STS D&P Division, M/C AC07
12214 Lakewood Blvd.
Downey, CA 90241
Phone: (213) 922-3785

Analysis Engineers:
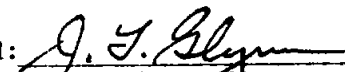
H. Sexton & D. Schlosser
Rockwell International
STS D&P Division, M/C AC07
12214 Lakewood Blvd.
Downey, CA 90241
Phone: (213) 922-3551

Data Management Services:

Prepared by: Liaison  --  S. R. Houlihan
Operations - C. R. Edwards

Reviewed by:  M. M. Mann

Approved: _J. J. Glynn_
J. L. Glynn, Manager
Data Operations

Concurrence: _N. D. Kemp_
N. D. Kemp, Manager
Data Management Services

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RESULTS OF TESTS FOR FORCE, MOMENT, PRESSURE AND
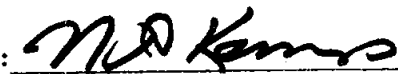AEROELASTIC DATA USING THE 0.030 SCALE PRESSURE
LOADS SPACE SHUTTLE ORBITER MODEL (47-0) IN THE
NASA/ARC 11 FOOT UNITARY PLAN WIND TUNNEL,
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Rockwell International STS D&P Division

ABSTRACT

An experimental investigation (test OA400) was conducted in the 11x11-
foot leg of the NASA/ARC Unitary Plan Wind Tunnel from 23 April to 2 May
1980. The objectives of the test were to obtain airloads information
with and without the SILTS pod, obtain OV102 wing distributed airloads,
obtain elevon distributed airloads and hinge moments and determine the
effect of vertical tail aeroelasticity on the lateral-directional charac-
teristics of the orbiter vehicle.

Six-component force data, distributed pressure data on the right-hand
wing, aft fuselage, OMS pod and vertical tail and wing loads and elevon
hinge moments were measured at Mach numbers from 0.60 to 1.40 at angles
of attack from $-4^{\circ}$ to $16^{\circ}$ and at angles of sideslip from $-8^{\circ}$ to $8^{\circ}$.

Aeroelastic effects were measured by obtaining six component balance
data at Mach numbers from 1.1 to 1.4 at angles of attack from $-8^{\circ}$ to $10^{\circ}$
and angles of sideslip from $-8^{\circ}$ to $+8^{\circ}$. Tunnel dynamic pressure varied
from 600 psf to 1600 psf or to the tunnel operating limit, whichever came
first.

Test OA400 consists of three volumes:

Volume 1 – Force Data Plots and Tabulations[1]
Volume 2 – Pressure Data Plots
Volume 3 – Pressure Data Tabulations (Microfiche)[2]

NOTES:

[1]   Wing balance data coefficients CTW, CNW, CBW are omitted at this time.  They will be available when ARC provides corrected data.

[2]   Distribution of Volume 3 was limited due to the volume of micro-fiche.  Requests for pressure data tabulations should be directed to Chrysler Data Management Services.

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# INTRODUCTION

The 0.03 scale model (47-0) of the Space Shuttle Orbiter was tested from April 23 to May 2, 1980 in the 11x11 foot leg of the NASA/ARC Unitary Plan Wind Tunnel.

There were three separate and somewhat unrelated objectives to this test. The first was to obtain SILTS (Shuttle Infrared Leeside Temperature Sensor) pod airloads and vertical tail airloads in the presence of the SILTS pod. These data will be used in the design and venting analysis of the vertical tail/SILTS pod. The second objective of this test was to obtain distributed loads on the wing and aft fuselage. The OV102 wing had not previously been run at these mach numbers. Elevon distributed loads, wing loads (3-component), and elevon hinge moments were recorded as part of this requirement. The third objective of this test was to re-test the aeroelastic effects of the vertical tail on the lateral-directional stability characteristics of the orbiter at transonic mach numbers. Comparisons were made between a rigid (steel) vertical and a specially constructed flexible (aluminum and rubber) vertical.

For the loads portion of the test, the mach number ranged from 0.6 to 1.4, the angle of attack from $-4^{\circ}$ to $16^{\circ}$ and the angle of sideslip from $-8^{\circ}$ to $8^{\circ}$.

The nominal flight dynamic pressure over these mach number ranges is 600 psf and the entire loads test was run at that pressure. The aeroelastic vertical tail was designed to flex under load in the same shapes and

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frequency as the flight article but was scaled to a stiffness three times greater than scale. Because of this a tunnel dynamic pressure of 1800 psf was desirable to properly match the flight conditions. This pressure, however, is beyond the capability of the tunnel at some mach numbers and exceeds the structural limits of the model at others. Because of these limitations the maximum dynamic pressure obtained varies with mach number and model attitude.

The three percent scale model of the orbiter reentry configuration was sting-mounted through a hole in the base plate. Clearance for the sting necessitated removing approximately half of each of the simulated engine nozzles.

The model was supported by a Task Mk XB six-component balance throughout the entire test. Elevon hinge moments and wing bending and torsion were measured during the loads portion of the test only.

A maximum of 500 pressures were measured during the loads portion of the test. All pressures were measured by sixteen model mounted scanivalves. Two drive/steppers were used to drive eight valves each.

During the aeroelastic vertical tail testing, all cables and tubes were removed from the outside of the sting to eliminate any possible mechanical interference between the metric and non-metric parts of the installation. Because of this, no base pressure or wing or elevon data were recorded during this phase of the test.

This report consists of 1 volume of force data, 1 volume of plotted pressure data, and 1 volume of tabulated pressure data on microfiche.

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The volumes are arranged in the following manner:

| Volume Number | CONTENTS | Microfiche Page No. |
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NOMENCLATURE

| SYMBOL | MNEMONIC | DEFINITION |
|---|---|---|
| $A_b$ | AB | total orbiter base area, $ft^2$ |
| $A_c$ | AC | sting cavity area, $ft^2$ |
| $A_i$ | Ai | area over which $P_i$ acts, $ft^2$ |
| AF | | balance axial force, lb. |
| Base | BASE | base (non-dimensional) |
| $b_v$ | BV | vertical tail reference span, in. |
| Bw | | wing balance bending moment, in-lbs. |
| $b_w$ | BREF, BW | orbiter wing span, in. |
| $C_A$ | CA | orbiter axial force coefficient with sting cavity adjusted to average base pressure |
| $C_{A_B}$ | CAB | orbiter axial force base pressure coefficient |
| $C_{A_c}$ | CAC | orbiter sting cavity axial force coefficient |
| $C_{A_F}$ | CAF | orbiter forebody axial force coefficient |
| $C_{A_u}$ | CAU | orbiter uncorrected axial force coefficient |
| $C_{B_w}$ | CBW | wing bending moment coefficient |
| $C_D$ | CD | orbiter drag coefficient |
| $c_e$ | | elevon reference chord, in. |
| $C_{h_{ei}}$ | CHEI | inner elevon hinge moment coefficient, about hinge line $X_0 = 1387.0$ |
| $C_{h_{eo}}$ | CHEO | outer elevon hinge moment coefficient, about hinge line $X_0 = 1387.0$ |
| $C_L$ | CL | orbiter lift coefficient |
| $C_\ell$ | CBL | orbiter rolling moment coefficient, body axis system |

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| SYMBOL | MNEMONIC | DEFINITION |
|--------|----------|------------|
| $C_m$ | CLM | orbiter pitching moment coefficient with sting cavity adjusted to average base pressure referenced to orbiter MRC |
| $C_{m_b}$ | CMB | orbiter pitching moment base pressure coefficient |
| $C_{m_F}$ | CLMF | orbiter forebody pitching moment coefficient referenced to orbiter MRC |
| $C_{m_{sc}}$ | CLMSC | orbiter sting cavity pitching moment coefficient, referenced to orbiter MRC |
| $C_{m_u}$ | CLMU | orbiter uncorrected pitching moment coefficient |
| $C_n$ | CYN | orbiter yawing moment coefficient, body axis system |
| $C_N$ | CN | orbiter normal force coefficient with sting cavity adjusted to average base pressure |
| $C_{N_B}$ | CNB | orbiter base pressure normal force coefficient |
| $C_{N_F}$ | CNF | orbiter forebody normal force coefficient |
| $C_{N_u}$ | CNU | orbiter uncorrected normal force coefficient |
| $C_{N_W}$ | CNW | wing normal force coefficient |
| $C_{PB_{avg}}$ | -- | average base pressure coefficient for specified taps |
| $C_{PC_{avg}}$ | -- | average cavity pressure coefficient for specified taps |
| $C_{pi}$ | CPi | surface tap pressure coefficient, port i, $(P_i - P_\infty)/q$ |
| $C_{T_W}$ | CTW | wing torsion coefficient |
| $C_W$ | -- | wing balance chord, in. |
| $C_Y$ | CY | orbiter side force coefficient |

| SYMBOL | MNEMONIC | DEFINITION |
|--------|----------|------------|
| $\ell_{REF}$ | LREF | longitudinal reference length, orbiter mean aerodynamic chord, in. |
| M | MACH | freestream Mach number |
| NF | – | balance normal force, lb. |
| $N_w$ | – | wing balance normal force, lbs. |
| $P_i$ | Pi | pressure at surface tap i, PSF |
| PM | | balance pitching moment, in-lb. |
| $P_o$ | PO | run-averaged freestream total pressure, PSF |
| $P_\infty$ | P | freestream static pressure, PSF |
| $P_t$ | PT | freestream total pressure, PSF |
| q | Q(PSF) | freestream dynamic pressure, PSF |
| RM | – | balance rolling moment, in-lb. |
| | RN/L | unit Reynolds number, million per foot |
| $S_e$ | SE | elevon reference area, $ft^2$ |
| SF | – | balance side force, lb. |
| SILTS | | Shuttle infrared leeside temperature sensor |
| $S_w$ | SREF | wing reference area, $ft.^2$ |
| $T_o$ | TO | run-averaged freestream total temperature, $^oF$ |
| | TTF | freestream total temperature, $^oF$ |
| $T_t$ | TTR | freestream total temperature, $^oR$ |
| $T_w$ | – | wing balance torsion, in-lbs. |
| X/C  X/$C_W$ | XW/CW | chordwise location on wing surface, fraction of local chord |

| SYMBOL | MNEMONIC | DEFINITION |
|--------|----------|------------|
| $X/C_{BF}$ | X/CBF | chordwise location on body flap, fraction of local chord |
| $X_{cp}$ | XCP/L | center of pressure location referred to $l_b$ |
| $X/C_{sb}$ | X/CSB | chordwise location on speedbrake, fraction of local chord |
| $X/C_v$ | XV/CV | chordwise location on vertical tail fraction of local chord |
| $X/L_{SILTS}$ | X/LS | longitudinal location on SILTS pod, fraction of pod length |
| $X_{mrp}$ | XMRP | longitudinal location of moment reference point |
| $X_o$ | XO | longitudinal distance in the orbiter reference system, inches |
| $X_o/L_o$ | X/LB | longitudinal location of body surface, fraction of body length |
| $Y_o$ | YO | lateral distance in the orbiter reference system, inches |
| $X_T$ | XT | longitudinal moment transfer distance from orbiter balance center to orbiter MRC, in. |
| $Y_{mrp}$ | YMRP | lateral location of moment reference point |
| $Z/b_{sb}$ | Z/BSB | spanwise location on speedbrake, fraction of span |
| $Z_{mrp}$ | ZMRP | vertical location of moment reference point |
| $Z_o$ | ZO | vertical distance in the orbiter reference system, inches |
| $Z_T$ | ZT | vertical moment transfer distance from orbiter balance center to orbiter MRC, in. |
| $\alpha$ | ALPHA | angle of attack, degrees |
| $\beta$ | BETA | angle of sideslip, degrees |

| SYMBOL | MNEMONIC | DEFINITION |
|---|---|---|
| $\delta_{bf}$ | BDFLAP | body flap deflection, degrees |
| $\delta_{eI}$ | IB-ELV | inboard elevon deflection, degrees |
| $\delta_{eL}$ | L-ELVN | left elevon deflection, degrees |
| $\delta_{eO}$ | OB-ELV | outboard elevon deflection, degrees |
| $\delta_{eR}$ | R-ELVN | right elevon deflection, degrees |
| $\delta_{eR_I}$ | RI-ELV | right inboard elevon deflection, degrees |
| $\delta_{eR_O}$ | RO-ELV | right outboard elevon deflection, degrees |
| $\delta_r$ | RUDDER | rudder deflection, degrees |
| $\delta_{sb}$ | SPDBRK | speed brake deflection, degrees |
| $\eta$ <br> $2Y/BW$ | Y/BW | spanwise location on wing, fraction of semi-span |
| $\eta_{bf}$ <br> $Y/b_{BF}$ | Y/BBF | lateral location on body flap, fraction of span |
| $\eta_v$ | Z/BV | spanwise location on vertical tail, fraction of vertical tail span |
| $\phi$ | PHI | angular cylindrical coordinate position around orbiter, body, deg. <br> (or on SILTS pod about its centerline) |

# CONFIGURATIONS INVESTIGATED

The test article used for test OA400 is an 0.03-scale replica of the Rockwell International Space Shuttle Orbiter Vehicle known as Model 47-0. The model configuration represented the reentry configuration. The orbiter is of blended wing/body design with a double-delta wing planform with leading edge sweep angles of $81^O$ and $45^O$. The wing section is 12% thick and has full span elevons with a 6" interpanel gap between the independently deflectable inboard and outboard panels. A single swept ($45^O$) centerline vertical tail with rudder/speedbrake capability is mounted between two Orbital Maneuvering System (OMS) pods. At the lower aft end of the fuselage is a body flap to aid trim control when the speedbrakes are used during reentry. Three Space Shuttle Main Engines (SSME) are mounted on the blunt base of the orbiter fuselage. On the model these nozzles and the base plate are partially cut away to provide clearance for the mounting sting. The general arrangement of the orbiter is shown in figure 2a.

The orbiter fuselage is built to conform to control drawing VL70-000140A and the OMS pods to drawing VL70-000140C. The basic vertical tail is defined by drawing VL70-000146A and the vertical tail with SILTS conforms to PCD V70-900-015. The wing is the Orbiter Vehicle 102 wing as defined in the MD-V70 data book.

The model is built of aluminum fairing pieces around a steel backbone/balance block. Three vertical tails were used during this test.

The basic vertical is built of steel and is instrumented with 76 pressure taps on the fin and 30 on the speedbrake/rudder panel. The SILTS vertical is built of steel and is instrumented with 83 pressure taps on the fin, 26 on the SILTS pod and 30 on the speedbrake/rudder panel. The third vertical is aeroelastic. It is constructed with a tuned aluminum spar covered with a special low elasticity rubber compound. This vertical has the same rudder/speedbrake settings as the two rigid verticals and is designed to flex and twist under load to the same values as the flight hardware. The flexible vertical tail was also tested with a simulated SILTS pod.

The following nomenclature was used to define the orbiter configuration.

| NOMENCLATURE | ORBITER COMPONENT |
|---|---|
| B62 | Body |
| C9 | Canopy |
| E64 | Elevons |
| W131 | Wing |
| M16 | OMS (Orbital Maneuvering System) pods |
| N112 | Main engine nozzles (SSME) (cut away for sting) |
| F9 | Body flap |
| R5 | Rudder |
| V8 | Basic vertical tail |
| V29 | Vertical tail with SILTS pod |
| FD3 | Flipper doors |
| N28 | OMS nozzles |

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# INSTRUMENTATION

Orbiter loads were measured using a Task 2.5" Mk XB six-component balance mounted in the orbiter fuselage by means of a straight sting. Wing loads were measured using a three component gaged beam built into the wing root. Elevon hinge moments were measured using a single gaged beam in the right hand inboard and outboard elevons. The left hand elevons each contained identical beams to their right hand counterparts to insure equal flexibility under load but these were not instrumented. The flexible vertical tail was instrumented with a three component gaged spar that was used to monitor ultimate and dynamic failure loads only (see figure 2k). No useable aerodynamic data were collected from the flexible vertical tail balance.

Pressure data were recorded by sixteen scanivalve units mounted in the orbiter body. Two drive motors (8 valves each) were used to step the valves. Figure 2 shows the location of all pressure taps on the model.

All instrumentation except the main balance were disconnected during the flexible tail portion of the test to prevent interference due to cables and tubes where they cross from the metric model to the non-metric sting.

# TEST FACILITY DESCRIPTION

The NASA/Ames Research Center is located at Moffett Field, Mountain View, California. The Unitary Plan Wind Tunnel consists of three separate wind tunnel circuits all driven by one common motor.

The 11x11-foot leg of this facility is a variable density, closed return, continuous flow transonic wind tunnel. The tunnel can operate at mach numbers from 0.4 to 1.4 at total pressures to 60 inches of mercury. The test section has slotted walls to control boundary layer bleed and minimize shock reflection. Test section mach number is controlled by wall suction and by a variable throat upstream of the test section consisting of two flexible moveable walls.

# DATA REDUCTION

Standard NASA/ARC data reduction techniques were used to reduce forces, moments and pressures to engineering units. Presented below are only those equations which are non-standard or that help clarify other data.

All force data were reduced about the orbiter moment reference center located at:

$$X_O = 1076.68 \text{ inches (full scale)}$$

$$Y_O = 0$$

$$Z_O = 375 \text{ inches (full scale)}$$

Uncorrected Force Coefficients

$$C_{N_u} = \frac{NF}{q\ S_w} \quad \text{(Normal force coefficient)}$$

$$C_{A_u} = \frac{AF}{q\ S_w} \quad \text{(Axial force coefficient)}$$

$$C_Y = \frac{SF}{q\ S_w} \quad \text{(Side force coefficient)}$$

$$C_m = \frac{PM}{q\ S_w c_w} + \frac{C_{A_u}\ Z_T}{c_w} - \frac{C_{N_u}\ X_T}{c_w} \quad \begin{array}{l}\text{(Pitching} \\ \text{Moment Coefficient)}\end{array}$$

$$C_n \quad \frac{YM}{q\ S_w b_w} - \frac{C_Y\ X_T}{b_w} \quad \begin{array}{l}\text{(Yawing Moment} \\ \text{Coefficient - Body Axis)}\end{array}$$

$$C_\ell = \frac{RM}{q\ S_w b_w} + \frac{C_Y\ Z_T}{b_w} \quad \begin{array}{l}\text{(Rolling Moment} \\ \text{Coefficient - Body Axis)}\end{array}$$

where
$X_T = 0.572$ inches (model scale)
$Y_T = 0.0$ inches (model scale)
$Z_T = 0.450$ inches (model scale)
$S_w = 2690.0$ ft$^2$ (full scale)
$c_w = 474.81$ inches (full scale)
$b_w = 936.68$ inches (full scale)

Normal Force Coefficient corrected for base pressures (Forebody Normal Force Coefficient):

$$C_{N_F} = C_{N_u} - C_{N_B}$$

$$C_{N_B} = -\frac{1}{S_w} \left\{ (\tan 14.75^\circ) \sum_{i=301}^{318} CP_i A_i + \sum_{i=401}^{440} CP_i A_i \right\}$$

Axial Force Coefficient corrected for sting cavity pressure:

$$C_A = C_{A_u} - C_{A_c}$$

$$C_{A_c} = (CP_{Bavg} - CP_{Cavg}) \frac{A_c}{S_w}$$

$$CP_{Bavg} = \frac{CP_{306} + CP_{307} + CP_{308} + CP_{309} + CP_{312} + CP_{313}}{6}$$

$$CP_{Cavg} = \frac{CP_{304} + CP_{310}}{2}$$

Axial Force corrected for base pressure (Forebody Axial Force Coefficient):

$$C_{A_F} = C_A - C_{A_B}$$

$$C_{A_B} = -\frac{1}{S_w} \left\{ \sum_{i=301}^{324} CP_i A_i + CP_{Bavg} - A_c \right\}$$

Pitching Moment Coefficient corrected for base pressure effects (Forebody Pitching Moment Coefficient):

$$C_{m_F} = C_{m_u} - C_{m_B}$$

$$C_{m_B} = -\frac{1}{S_w \, c_w} \left\{ - XB_1 (\tan 14.75^\circ) \sum_{i=301}^{318} CP_i A_i \right.$$

$$\left. - XB_2 \sum_{i=401}^{440} CP_i A_i + ZB \sum_{i=301}^{324} CP_i A_i \right\}$$

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where $XB_1$ = 12.640 inches (model scale)
$XB_2$ = 14.640 inches (model scale)
$ZB$ = 0.450 inches (model scale)

Wing loads were determined by applying the output of the three component wing balance to a 3x3 matrix developed during post-test calibrations. Wing forces and moments were resolved at:

$X_O$ = 1307.0 inches (full scale)
$Y_O$ = 105.0 inches (full scale)
$Z_O$ = 288.0 inches (full scale)

Wing load coefficients were determined:

$$C_{N_W} = \frac{Nw}{q\ S_W} \quad \text{(Wing Normal Force Coefficient)}$$

$$C_{B_W} = \frac{Bw}{q\ S_W b_W} \quad \text{(Wing Bending Moment Coefficient)}$$

$$C_{T_W} = \frac{Tw}{q\ S_W c_W} \quad \text{(Wing Torsion Coefficient)}$$

Elevon hinge moment coefficients were determined:

$$C_{h_{ei}} = \frac{H_{ei}}{qS_e c_e}$$

$$C_{h_{ei}} = \frac{H_{eo}}{qS_e c_e}$$

where $H_{ei}$ = Inboard elevon hinge moment
$H_{eo}$ = Outboard elevon hinge moment
$S_e$ = Elevon reference area = 210.0 ft$^2$ (full scale)
$c_e$ = Elevon reference length = 90.7 inches (full scale)

All reference dimensions and constants used for data reduction are listed below in model scale:

## Model Areas

| | | |
|---|---|---|
| $A_C$ | 0.05476 | $ft^2$ |
| $A_{301}$ | 0 | |
| $A_{302}$ | 0 | |
| $A_{303}$ | 0.09656 | $ft^2$ |
| $A_{304}$ | 0 | |
| $A_{305}$ | 0 | |
| $A_{306}$ | 0.00530 | $ft^2$ |
| $A_{307}$ | 0.00796 | $ft^2$ |
| $A_{308}$ | 0.010613 | $ft^2$ |
| $A_{309}$ | 0.013230 | $ft^2$ |
| $A_{310}$ | 0 | |
| $A_{311}$ | 0.023217 | $ft^2$ |
| $A_{312}$ | 0.016584 | $ft^2$ |
| $A_{313}$ | 0.001327 | $ft^2$ |
| $A_{314}$ | 0.011940 | $ft^2$ |
| $A_{315}$ | 0.013798 | $ft^2$ |
| $A_{316}$ | 0.007297 | $ft^2$ |
| $A_{317}$ | 0.012603 | $ft^2$ |
| $A_{318}$ | 0.017247 | $ft^2$ |
| $A_{319}$ | 0.021758 | $ft^2$ |
| $A_{320}$ | 0.015920 | $ft^2$ |
| $A_{321}$ | 0.017247 | $ft^2$ |
| $A_{322}$ | 0.014328 | $ft^2$ |
| $A_{323}$ | 0.006103 | $ft^2$ |
| $A_{324}$ | 0.026003 | $ft^2$ |
| $A_{401}$ | 0 | |
| $A_{402}$ | 0 | |
| $A_{403}$ | 0 | |
| $A_{404}$ | 0 | |
| $A_{405}$ | 0.011551 | $ft^2$ |
| $A_{406}$ | 0.010267 | $ft^2$ |
| $A_{407}$ | 0.009838 | $ft^2$ |
| $A_{408}$ | 0.0077004 | $ft^2$ |
| $A_{409}$ | 0 | |
| $A_{410}$ | 0 | |
| $A_{411}$ | 0 | |
| $A_{412}$ | 0 | |
| $A_{413}$ | 0.012834 | $ft^2$ |

## Model Areas - Continued

| | |
|---|---|
| $A_{414}$ | $0.012834$ ft.$^2$ |
| $A_{415}$ | $0.012834$ ft.$^2$ |
| $A_{416}$ | $0.012834$ ft.$^2$ |
| $A_{417}$ | $0$ |
| $A_{418}$ | $0$ |
| $A_{419}$ | $0$ |
| $A_{420}$ | $0$ |
| $A_{421}$ | $0$ |
| $A_{422}$ | $0$ |
| $A_{423}$ | $0$ |
| $A_{424}$ | $0$ |
| $A_{425}$ | $0$ |
| $A_{426}$ | $0$ |
| $A_{427}$ | $0$ |
| $A_{428}$ | $0$ |
| $A_{429}$ | $0$ |
| $A_{430}$ | $0$ |
| $A_{431}$ | $0$ |
| $A_{432}$ | $0$ |
| $A_{433}$ | $0$ |
| $A_{434}$ | $0$ |
| $A_{435}$ | $0$ |
| $A_{436}$ | $0$ |
| $A_{437}$ | $0.011551$ ft.$^2$ |
| $A_{438}$ | $0.010267$ ft.$^2$ |
| $A_{439}$ | $0.0089838$ ft.$^2$ |
| $A_{440}$ | $0.0077004$ ft.$^2$ |

## Reference Dimensions (model scale)

| | |
|---|---|
| $S_W$ | $2.4210$ ft. |
| $S_e$ | $0.1890$ ft. |
| $b_W$ | $28.1004$ inches |
| $c_W$ | $14.244$ inches |
| $c_e$ | $2.721$ inches |

DATA REDUCTION (Concluded)

Transfer Distances (model scale)

| | | |
|---|---|---|
| $X_T$ | 0.572 | inches |
| $Y_T$ | 0.0 | inches |
| $Z_T$ | 0.450 | inches |
| $XB_1$ | 12.640 | inches |
| $XB_2$ | 14.640 | inches |
| $ZB$ | 0.450 | inches |

# TABLE I.

| TEST : OA 400 | | | DATE : 12 Sept 80 |
|---|---|---|---|
| **TEST CONDITIONS** | | | |

| MACH NUMBER | REYNOLDS NUMBER (per unit length) | DYNAMIC PRESSURE (pounds/sq. inch) | STAGNATION TEMPERATURE (degrees Fahrenheit) |
|---|---|---|---|
| 0.6 | $4.88 \times 10^6$ | 600 | $90°$ |
| 0.9 | 3.60 | " | " |
| 1.1 | 3.197 | " | " |
| 1.25 | 2.995 | " | " |
| 1.40 | 2.917 | " | " |
| | | | |
| | Force Data (q ramps) | | |
| | | | |
| 1.1 | 3.18 → 6.11 | 600 → 1200 | $90°$ |
| 1.2 | 3.03 → 7.52 | 600 → 1600 | " |
| 1.3 | 2.89 → 8.56 | 600 → 1800 | " |
| 1.4 | 2.87   5.42 | 600 → 1200 | " |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

BALANCE UTILIZED: __Rockwell Task 2.5" Mk X B__

| | CAPACITY: | ACCURACY: | COEFFICIENT TOLERANCE: |
|---|---|---|---|
| NF | 5500/8500 lbs | _____ | _____ |
| SF | 2750/2750 lbs | _____ | _____ |
| AF | 1250 lbs | _____ | _____ |
| PM | _____ | _____ | _____ |
| RM | 4000 in-lbs | _____ | _____ |
| YM | _____ | _____ | _____ |

COMMENTS:

TABLE II

Red MAR 6/2/80

| TEST: ØA 400   FLEX TAIL | DATA SET/RUN NUMBER COLLATION SUMMARY | DATE: 5/29/80 |
|---|---|---|

| DATA SET IDENTIFIER | CONFIGURATION | | | SCHD. | | CONTROL DEFLECTION | | | | NO. OF RUNS | MACH NUMBERS ( OR ALTERNATE INDEPENDENT VARIABLE ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | α | β | $\delta_{SB}$ | $\delta_R$ | Q | RAMP | | | 1.1 | 1.2 | 1.3 | 1.4 | |
| R3X001 | Orbiter (tail off) | | | A | -5 | – | – | 1200 | | | | | 38 | | | |
| 02 | | | | A | 0 | – | – | 900 | | | | | 34 | | | |
| 03 | | | | A | 0 | – | – | 1600 | | | | | 35 | | | |
| 04 | | | | A | 5 | – | – | 1200 | | | | | 37 | | | |
| 05 | | | | 5 | D | – | – | 900 | | | | | 33 | | | |
| 06 | | | | 5 | D | – | – | 1600 | | | | | 32 | | | |
| 07 | | | | 10 | D | – | – | 1600 | | | | | 36 | | | |
| 08 | (Tail on Slats off) | | | A | 0 | 0 | 0 | 1200 | | | | | 17 | 22 | | |
| 09 | | | | A | 5 | | | | | | | | 16 | 23 | | |
| 10 | | | | -5 | B | | | | | | | | 19 | 9 | | |
| 11 | | | | 0 | B | | | | | | | | 14 | | | |
| 12 | | | | 5 | B | | | | | | | | 20 | 21 | | |
| 13 | | | | -5 | 0 | | ↓ | | | | | | 15 | | | |
| 14 | | | | -5 | -2 | | V | | | | | | 27 | 29 | | |
| 15 | | | | -5 | 0 | | T | | | | | | 18 | 24 | | |
| 16 | | | | -5 | 1 | | | | | | | | 26 | 28 | | |
| 17 | | | | -5 | 2 | | | | | | | | 3 | 4 | | |
| 18 | | | | -5 | 5 | | | | UP | | | | 11 | 5 | | |

See Page 31 for Force and Pressure Dataset Definition, including Coefficient Schedule

$\delta_{EI} = \delta_{CO} = \delta_{BF} = 0$

COEFFICENTS

| α OR β SCHEDULES | A) -8° → 10°, Δα 2° <br> B) -4° → 5° Δβ 1° | D) -8, -6, -4, -2, 0, 2, 4, 5, 6, 8° | IDVAR (1)   IDVAR (2)   NDV |
|---|---|---|---|

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TABLE II (Continued)

| TEST: OA 400  FLEX TAIL | DATA SET/RUN NUMBER COLLATION SUMMARY | DATE: 5/29/80 |
|---|---|---|

| DATA SET IDENTIFIER | CONFIGURATION | SCHD. $\alpha$ | $\beta$ | $\delta_{SB}$ | $\delta_R$ | Q | Rconf | NO. OF RUNS | | | | | 1.1 | 1.2 | 1.3 | 1.4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23X019 | Orbiter (TA IN SILTS OFF) | -5 | 5 | 0 | 0 | V | 1out | | | | | | | 12 | 7 | | | | | |
| 20 | | -5 | 5 | 0 | 0 | V | | | | | | | | 13 | | | | | | |
| 21 | | 5 | -2 | 26.99 | -.03 | V | | | | | | | | 91 | | | | | | |
| 22 | | | 0 | | | V | | | | | | | | 89 | | | | | | |
| 23 | | | 2 | | | V | | | | | | | | 90 | | | | | | |
| 24 | | | 5 | | | V | | | | | | | | 96 | | | | | | |
| 25 | | | 0 | 26.62 | 9.93 | V | | | | | | | | 86 | | | | | | |
| 26 | | | 0 | 26.62 | 9.93 | V | | | | | | | | 27 | | | | | | |
| 27 | | | B | 26.99 | -.03 | 600 | | | | | | | | 25 | | | | | | |
| 28 | | | | | | 800 | | | | | | | | 94 | | | | | | |
| 29 | | | | | | 1000 | | | | | | | | 93 | | | | | | |
| 30 | | | | | | 1200 | | | | | | | | 92 | | | | | | |
| 31 | | C | 0 | 56.67 | | 1200 | | | | | | | 66 | 57 | | 58 | | | | |
| 32 | | C | 2 | | | 1200 | | | | | | | 67 | 56 | | 59 | | | | |
| 33 | | 5 | B | | | 600 | | | | | | | 64 | 50 | | 49 | | | | |
| 34 | | | B | | | 800 | | | | | | | 63 | 51 | | 48 | | | | |
| 35 | | | B | | | 1000 | | | | | | | 62 | 52 | | 47 | | | | |
| 36 | | | B | | | 1200 | | | | | | | 61 | 53 | | 44 | | | | |

$\delta_c = \delta_{e\beta} = \delta_{\beta\beta} = 0$

See Page 31  for Force and Pressure Dataset Definition, including Coefficient Schedule

COEFFICENTS

| $\alpha$ OR $\beta$ SCHEDULES | B) $= -4° \rightarrow 5°$  $\Delta\beta = 1°$ | IDVAR (1) | IDVAR (2) | NDV |
|---|---|---|---|---|
| | C) $= -2° \rightarrow 10°$  $\Delta\alpha = 2°$ | | | |

TABLE II (Continued)

| TEST: $\phi A\,400$  FLEX TAIL | | | \multicolumn{3}{c}{DATA SET/RUN NUMBER COLLATION SUMMARY} | | | | DATE: 5/29/80 | | |

| DATA SET IDENTIFIER | CONFIGURATION | | SCHD. | | CONTROL DEFLECTION | | | NO. OF RUNS | MACH NUMBERS ( OR ALTERNATE INDEPENDENT VARIABLE ) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\alpha$ | $\beta$ | $\delta_{SB}$ | $\delta_R$ | Q | | | | 1.1 | 1.2 | 1.3 | 1.4 | | |
| R3X037 | ORBITER | (TAIL ON SILTS OFF) | C | 0 | 56.24 | 9.24 | 1200 | | | | | 74 | | 72 | | |
| 38 | | | 5 | 0 | 56.24 | 9.24 | V | | | | 75 | 73 | | 71 | | |
| 39 | | | | -2 | 56.67 | -.03 | | | | | 68 | 40 | | 46 | | |
| 40 | | | | 0 | | | | | | | 65 | 54 | | 57 | | |
| 41 | | | | 2 | | | | | | | 60 | 41 | | 43 | | |
| 42 | | (TAIL ON SILTS ON) | | 0 | | | | | | | | | | 80 | | |
| 43 | | | | 0 | 56.24 | 9.24 | | | | | | | | 77 | | |
| 44 | | | C | 0 | 56.24 | 9.24 | 1200 | | | | | | | 78 | | |
| 45 | | | 5 | B | 56.67 | -.03 | 600 | | | | | | | 81 | | |
| 46 | | | | | | | 800 | | | | | | | 82 | | |
| 47 | | | | | | | 1000 | | | | | | | 83 | | |
| 48 | | | | | | | 1200 | | | | | | | 84 | | |

See Page 31 for Force and Pressure Dataset Definition, including Coefficient Schedule

$\delta_{EL} = \delta_{EO} = \delta_{BF} = 0$

COEFFICENTS

| $\alpha$ OR $\beta$ SCHEDULES | B) $-4° \rightarrow 5°$, $\Delta\beta = 1°$ | | | IDVAR (1)  IDVAR (2)  NDV |
| | C) $-2° \rightarrow 10°$  $\Delta\alpha = 2°$ | | | |

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TEST RUN NUMBERS

TABLE II (Continued)

ARC427-1-11

**TEST: DA400 (Pressure)** — DATA SET/RUN NUMBER COLLATION SUMMARY — **DATE: 3 June 80**

| DATA SET IDENTIFIER | CONFIGURATION | | β | M | $\delta_{eu}$ | $\delta_{eR}$ | $\delta_{sB}$ | $\delta_R$ | $\delta_{BF}$ | | | | | | -4 | 0 | 3.5 | 8 | 12 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R3X * 50 | ORBITER (SILTS OFF) | | B | .60 | 0 | 0 | 0 | 0 | -11.7 | | | | | | 13 | 14 | 15 | 16 | 17 | |
| 51 | | | | .90 | | | | | | | | | | | 18 | 19 | 20 | 21 | 22 | |
| 52 | | | | 1.10 | | | | | | | | | | | 23 | 24 | 25 | 26 | 27 | |
| 53 | | | | 1.25 | | | | | | | | | | | 31 | 32 | 33 | 34 | 35 | |
| 54 | | | | 1.40 | | | | | | | | | | | 36 | 37 | 38 | 39 | 40 | 41 |
| 55 | ORBITER (SILTS ON) | | | .60 | | | | | | | | | | | 64 | 65 | 66 | 67 | 68 | |
| 56 | | | | .90 | | | | | | | | | | | 59 | 60 | 61 | 62 | 63 | |
| 57 | | | | 1.10 | | | | | | | | | | | 54 | 55 | 56 | 57 | 58 | |
| 58 | | | | 1.25 | | | | | | | | | | | 49 | 50 | 51 | 52 | 53 | |
| 59 | | | | 1.40 | | | | | | | | | | | 43 | 44 | 45 | 46 | 47 | 48 |
| 60 | | | | .60 | | | | 10° | | | | | | | 92 | 93 | 94 | 95 | 96 | |
| 61 | | | | .90 | | | | | | | | | | | 87 | 88 | 89 | 90 | 91 | |
| 62 | | | | 1.10 | | | | | | | | | | | 82 | 83 | 84 | 85 | 86 | |
| 63 | | | | 1.25 | | | | | | | | | | | 77 | 78 | 79 | 80 | 81 | |
| 64 | | | | 1.40 | | | | | | | | | | | 71 | 72 | 73 | 74 | 75 | 76 |
| 65 | | | | .60 | | | | -10° | | | | | | | 119 | 120 | 121 | 122 | 123 | |
| 66 | | | | .90 | | | | | | | | | | | 114 | 115 | 116 | 117 | 118 | |
| 67 | | | | 1.10 | | | | | | | | | | | 109 | 110 | 111 | 112 | 113 | |

ALPHA (TEST RUN NUMBERS)

See Page 31 for Force and Pressure Dataset Definition, including Coefficient Schedule

α or β SCHEDULES

B) β = -8, -4, 0, 4, 8   COEFFICIENTS

Δ RUN 72 HAS NO β = +8

IDVAR (1)   IDVAR (2)   NDV

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TABLE II (Continued)

## ARC 427-1-11

| TEST: ΦA 460 (Pressure) | | | | | DATA SET/RUN NUMBER COLLATION SUMMARY | | | | | | | | | DATE: 3 June 80 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| DATA SET IDENTIFIER | CONFIGURATION | | $\beta$ | M | $\delta_{e_L}$ | $\delta_{e_R}$ | $\delta_{SB}$ | $\delta_R$ | $\delta_{BF}$ | | | | | ALPHA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | -4 | 0 | **3.5** | 8 | 12 | 16 |
| R3X *68 | ORBITER (SILTS ON) | | B | 1.25 | 0 | 0 | 0 | -10° | -11.7° | | | | | 104 | 105 | 106 | 107 | 108 | |
| 69 | | | | 1.40 | | | | | | | | | | 98 | 99 | 100 | 101 | 102 | 103 |
| 70 | | | | .60 | | | 55° | | 16.3 | | | | | 147 | 148 | 149 | 150 | 151 | |
| 71 | | | | .90 | | | | | | | | | | 142 | 143 | 144 | 145 | 146 | |
| 72 | | | | 1.10 | | | | | | | | | | 137 | 138 | 139 | 140 | 141 | |
| 73 | | | | 1.25 | | | | | | | | | | 132 | 133 | 134 | 135 | 136 | |
| 74 | | | | 1.40 | | | | | | | | | | 126 | 127 | 128 | 129 | 130 | 131 |
| 75 | | | | .60 | | | | 0° | | | | | | 176 | 177 | 178 | 179 | 180 | |
| 76 | | | | .90 | | | | | | | | | | 171 | 172 | 173 | 174 | 175 | |
| 77 | | | | 1.10 | | | | | | | | | | 166 | 167 | 168 | 169 | 170 | |
| 78 | | | | 1.25 | | | | | | | | | | 161 | 162 | 163 | 164 | 165 | |
| 79 | | | | 1.40 | | | | | | | | | | 153 | 154 | 155 | 156 | 157 | 158 |
| 80 | | | | .60 | | | | 10° | | | | | | 204 | 205 | 206 | 207 | 208 | |
| 81 | | | | .90 | | | | | | | | | | 199 | 200 | 201 | 202 | 203 | |
| 82 | | | | 1.10 | | | | | | | | | | 194 | 195 | 196 | 197 | 198 | |
| 83 | | | | 1.25 | | | | | | | | | | 189 | 190 | 191 | 192 | 193 | |
| 84 | | | | 1.40 | | | | | | | | | | 183 | 184 | 185 | 186 | 187 | 188 |

See Page 31 for Force and Pressure Dataset Definition, including Coefficient Schedule

α OR β SCHEDULES    B) $\beta = -8, -4, 0, 4, 8$   COEFFICIENTS          IDVAR (1)    IDVAR (2)    NDV

TEST RUN NUMBERS

28

TABLE II (Continued)

ARC 427-1-11

| TEST: ΦA400 (Pressure) | DATA SET/RUN NUMBER COLLATION SUMMARY | DATE: 3 June 80 |
|---|---|---|

| DATA SET IDENTIFIER | CONFIGURATION | β | M | $\delta_{eL}$ | $\delta_{eR}$ | $\delta_{SB}$ | $\delta_R$ | $\delta_{BF}$ | | | | | ALPHA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | -4 | 0 | 3.5 | 8 | 12 | 16 |
| R3X*85 | ORBITER (SILTS ON) | A | .60 | 0 | 0 | 85° | 0° | 22.5 | | | | | 231 | 232 | 233 | 234 | 235 | |
| 86 | | | 90 | | | | | | | | | | 226 | 227 | 228 | 229 | 230 | |
| 87 | | | 1.10 | | | | | | | | | | 221 | 222 | 223 | 224 | 225 | |
| 88 | | | 1.25 | | | | | | | | | | 216 | 217 | 218 | 219 | 220 | |
| 89 | | | 1.40 | | | | | | | | | | 210 | 211 | 212 | 213 | 214 | 215 |
| 90 | | | .60 | | | | 10° | | | | | | 258 | 259 | 260 | 261 | 262 | |
| 91 | | | 90 | | | | | | | | | | 253 | 254 | 255 | 256 | 257 | |
| 92 | | | 1.10 | | | | | | | | | | 248 | 249 | 250 | 251 | 252 | |
| 93 | | | 1.25 | | | | | | | | | | 243 | 244 | 245 | 246 | 247 | |
| 94 | | | 1.40 | | | | | | | | | | 237 | 238 | 239 | 240 | 241 | 242 |
| 95 | | | .60 | | | | -10° | | | | | | 285 | 286 | 287 | 288 | 289 | |
| 96 | | | 90 | | | | | | | | | | 280 | 281 | 282 | 283 | 284 | |
| 97 | | | 1.10 | | | | | | | | | | 275 | 276 | 277 | 278 | 279 | |
| 98 | | | 1.25 | | | | | | | | | | 270 | 271 | 272 | 273 | 274 | |
| 99 | | | 1.40 | | | | | | | | | | 264 | 265 | 266 | 267 | 268 | 269 |

See Page 31 for Force and Pressure Dataset Definition, including Coefficient Schedule

| α OR β SCHEDULES | A) β = -4, 0, 4    COEFFICIENTS | IDVAR (1)   IDVAR (2)   NDV |
|---|---|---|

TEST RUN NUMBERS

29

TABLE II (Continued)

ARC 427-1-11

| TEST: ΦA 400 (Pressure) | DATA SET/RUN NUMBER COLLATION SUMMARY | | | | | | | | | | | | DATE: 3 June 80 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| DATA SET IDENTIFIER | CONFIGURATION | | β | M | $\delta_{EL}$ | $\delta_{ER}$ | $\delta_{SB}$ | $\delta_R$ | $\delta_{BF}$ | | | | | ALPHA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | −4 | 0 | 3.5 | 8 | 12 | 16 |
| R3X*A1 | ORBITER (SILTS ON) | | B | .60 | 10° | 10° | 25° | 0° | 0° | | | | | 312 | 313 | 314 | 315 | 316 | |
| 2 | | | | 90 | | | | | | | | | | 307 | 308 | 309 | 310 | 311 | |
| 3 | | | | 1.10 | | | | | | | | | | 302 | 303 | 306 | 304 | 305 | |
| 4 | | | | 1.25 | | | | | | | | | | 297 | 298 | 299 | 300 | 301 | |
| 5 | | | | 1.40 | | | | | | | | | | 291 | 292 | 293 | 294 | 295 | 296 |
| 6 | ORBITER (SILTS OFF) | | | 1.25 | 0° | 0° | 0° | 0° | −11.7 | | | | | 28 | 29 | | | | |

See Page 31 for Force and Pressure Dataset Definitions including Coefficient Schedule

α OR β SCHEDULES    B) β = −8, −4, 0, 4, 8    COEFFICIENTS    IDVAR (1)    IDVAR (2)    NDV

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TEST RUN NUMBERS

TABLE II (Concluded)

ØA400

Force and Pressure Dataset Definition

FORCE DATA - COEFFICIENT SCHEDULES

        R3X001→48
MACH    Q(PSF) ALPHA,CL,CD,CLM,CY,CYN,CBL,CA,CN


        R3X050→99, R3XOA1→A6
ALPHA   BETA    MACH,CN,CA,CLM,CBL,CYN,CY,CNW*,CTW*,CBW*


        S3X001→48
MACH    Q(PSF) ALPHA,Q(PSF),PT,P,TTR,RI-ELV,RØ-ELV,BDFLAP,SPDBRK**, RUDDER**


        S3X050→99, S3XOA1→A6
ALPHA   BETA    MACH,Q(PSF),PT,P,TTF,CHEI,CHEØ,IB-ELV,ØB-ELV


        T3X050→99, T3XOA1→A6
ALPHA   BETA    MACH,CNF,CAF,CLMF,CAB,CAC,CNB,CMB


PRESSURE DATA - COMPONENTS

        Datasets R3X$50→99, R3X$A1→A6 contain CP for taps as follows:

        | $ | Component |
        |---|-----------|
        | U | Wing Upper Surface |
        | L | Wing Lower Surface |
        | V | Vertical Tail |
        | R | Right Side Vertical Tail |
        | E | Base Pressure |
        | F | Body Flap Top |
        | B | Aft Fuselage/OMS Pod |
        | C | Silts Sensor Taps |
        | P | Silts Pod |
        | K | Inside Speedbrake |

        (Datasets with first letter "C" are the corresponding "R" datasets
        with the corrections for bad points as delineated in Table VIII.)


*Provided upon availability of corrected data from ARC
**Parameter block contains corrected SPDBRK and RUDDER deflections

# TABLE III. WING PRESSURE TAP NUMBERS/LOCATIONS

**η = .235** (2Y/B)

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.70 | 0.80 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 |
| BOTT | | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | 621 |

**η = .299, Y₀ = 140**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.70 | 0.836 | 0.866 | 0.881 | 0.911 | 0.941 | 0.971 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | 631 | 633 | 634 | 635 | 636 | 637 | 638 | |
| BOTT | | 640 | 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 650 | 651 | 652 | 653 | 654 | 655 | 639 |

**η = .342, Y₀ = 160**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.70 | 0.809 | 0.843 | 0.861 | 0.895 | 0.930 | 0.964 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 656 | 657 | 658 | 659 | 660 | 661 | 662 | 663 | 664 | 665 | 667 | 668 | 669 | 670 | 671 | 672 | |
| BOTT | | 674 | 675 | 676 | 677 | 678 | 679 | 680 | 681 | 682 | 684 | 685 | 686 | 687 | 688 | 689 | 673 |

**η = .427, Y₀ = 200**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.758 | 0.802 | 0.824 | 0.868 | 0.912 | 0.956 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 690 | 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 700 | 701 | 702 | 703 | 704 | 705 | |
| BOTT | | 707 | 708 | 709 | 710 | 711 | 712 | 713 | 714 | 716 | 717 | 718 | 719 | 720 | 721 | 706 |

**η = .534, Y₀ = 250**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.738 | 0.786 | 0.810 | 0.858 | 0.906 | 0.954 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | 732 | 733 | 734 | 735 | 736 | 737 | |
| BOTT | | 739 | 740 | 741 | 742 | 743 | 744 | 745 | 746 | 748 | 749 | 750 | 751 | 752 | 753 | 738 |

**η = .619, Y₀ = 290**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.725 | 0.776 | 0.801 | 0.852 | 0.902 | 0.953 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 754 | 755 | 756 | 757 | 758 | 759 | 760 | 761 | 762 | 764 | 765 | 766 | 767 | 768 | 769 | |
| BOTT | | 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | | 781 | 782 | 783 | 784 | 785 | 770 |

**η = .726, Y₀ = 340**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.55 | 0.704 | 0.758 | 0.786 | 0.841 | 0.896 | 0.950 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 786 | 787 | 788 | 789 | 790 | 791 | 792 | 793 | 794 | 796 | 797 | 798 | 799 | 800 | 801 | |
| BOTT | | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 812 | | 814 | 815 | 816 | 817 | 802 |

**η = .811, Y₀ = 380**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.679 | 0.739 | 0.769 | 0.829 | 0.888 | 0.948 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 818 | 819 | 820 | 821 | 822 | 823 | 824 | 825 | 827 | 828 | 829 | 830 | 831 | 832 | |
| BOTT | | 834 | 835 | 836 | 837 | 838 | 839 | 840 | | | 844 | 845 | 846 | 847 | 833 |

**η = .897, Y₀ = 420**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.40 | 0.642 | 0.709 | 0.742 | 0.809 | 0.876 | 0.942 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 848 | 849 | 850 | 851 | 852 | 853 | 854 | 855 | 857 | 858 | 859 | 860 | 861 | 862 | |
| BOTT | | 864 | 865 | 866 | 867 | 868 | 869 | 870 | 872 | | 874 | 875 | 876 | 877 | 863 |

**η = .961, Y₀ = 450**

| X/Cw | 0.00 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.25 | 0.558 | 0.641 | 0.682 | 0.765 | 0.848 | 0.932 | 1.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOP | 878 | 879 | 880 | 881 | 882 | 883 | 884 | 886 | 887 | 888 | 889 | 890 | 891 | |
| BOTT | | 893 | 894 | 895 | 896 | 897 | 898 | 900 | | 902 | 903 | 904 | 905 | 892 |

**η = 1.00, TIP**

| X/Cw | 0.15 | 0.25 | 0.579 | 0.779 | 0.939 | 1.00 |
|---|---|---|---|---|---|---|
| TOP | 906 | 907 | 909 | 910 | 911 | 912 |
| BOTT | | | | | | |

# VERTICAL - WITHOUT SILTS

| $z_0$ | $\eta_v$ | $(X/C)_v$ | | | | | | | | | $\Sigma$ |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | O | .03 | .06 | .15 | .30 | .52 | .68 | .83 | .98 | |
| 530 | .095 | 501 | 502 | 503 | 504 | 505 | 506 | 507 | | | 7 |
| 570 | .222 | 509 | 570 | 511 | 512 | 513 | 574 | 515 | 516 | 517 | 16 |
| 600 | .317 | 518 | 579 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 25 |
| 640 | .443 | 527 | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 34 |
| 680 | .570 | 536 | 537 | 538 | 539 | 540 | 541 | 542 | 543 | 544 | 43 |
| 720 | .697 | 545 | 546 | 547 | 548 | 549 | 550 | 551 | 552 | 553 | 52 |
| 755 | .808 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 61 |
| 790 | .919 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | 571 | 70 |
| Tip | 1.00 | | | | 572 | 573 | 574 | 575 | 576 | | 75 |

# SPEED BRAKE

| $z_0$ full scale | $z_0$ Model scale | $\eta_{SB}$ | $(X/C)_{SB}$ | | | | | No Taps | $\Sigma$ |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | | .1 | .25 | .40 | .65 | .90 | | |
| 600 | 18.0 | .110 | 1801 | 1802 | 1803 | 1804 | 1805 | 5 | 5 |
| 630 | 18.9 | .254 | 1806 | 1807 | 1808 | 1809 | 1810 | 5 | 10 |
| 666 | 19.8 | .407 | 1811 | 1812 | 1813 | 1814 | 1815 | 5 | 15 |
| 690 | 20.7 | .567 | 1816 | 1817 | 1818 | 1819 | 1820 | 5 | 20 |
| 720 | 21.6 | .706 | 1821 | 1822 | 1823 | 1824 | 1825 | 5 | 25 |
| 750 | 22.5 | .856 | 1826 | 1827 | 1828 | 1829 | 1830 | 5 | 30 |

TABLE V.   SILTS VERTICAL TAIL PRESSURE TAP NUMBERS/LOCATIONS

| LOCATION | | | X/Cv | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $Z_0$ | $\eta_v$ | SIDE | 0 | .012 | .030 | .060 | .110 | .150 | .300 | .520 | .613 | .680 | .700 | .830 | .980 |
| 530 | .095 | LEFT | 3501 | | 3502 | 3503 | | 3504 | 3505 | 3506 | | 3507 | | | |
| 570 | .222 | | 3509 | | 3510 | 3511 | | 3512 | 3513 | 3514 | | 3515 | | 3516 | 3517 |
| 576 | .242 | | | | | | | | | | | | | 3592 | 3593 |
| 578 | .246 | | | | | | | | | | | | | 3595 | 3596 |
| 580 | .252 | | | | | | | | | | | 3591 | | | |
| 582 | .261 | | | | | | | | | | | | 3594 | | |
| 600 | .317 | | 3518 | | 3519 | 3520 | | 3521 | 3522 | 3523 | | 3524 | | 3525 | 3526 |
| 600 | .317 | RIGHT | | | 3577 | 3578 | | 3579 | 3580 | 3581 | | 3582 | | 3583 | |
| 640 | .443 | LEFT | 3527 | | 3528 | 3529 | | 3530 | 3531 | 3532 | | 3533 | | 3534 | 3535 |
| 680 | .570 | LEFT | 3536 | | 3537 | 3538 | | 3539 | 3540 | 3541 | | 3542 | | 3543 | 3544 |
| 680 | .570 | RIGHT | | | 3584 | 3585 | | 3586 | 3587 | 3588 | | 3589 | | 3590 | |
| 720 | .697 | LEFT | 3545 | | 3546 | 3547 | | 3548 | 3549 | 3550 | | | | 3552 | 3553 |
| 755 | .808 | | 3554 | | 3555 | 3556 | | 3557 | 3558 | 3559 | | | | 3561 | 3562 |
| 778 | .880 | | | | | | | | | | | | | 3598 | |
| 780 | .888 | | | | | | | | | | | | | 3600 | |
| 790 | .919 | | 3563 | | 3564 | 3565 | | 3566 | 3567 | 3568 | | 3569 | | 3570 | 3571 |
| 800 | .949 | | | 3603 | | | 3604 | | 3605 | | 3606 | | | | |

\* THESE TAPS ARE INCLUDED IN THE SILTS POD ARRAY ALSO

TABLE VI.   SILTS POD PRESSURE TAP NUMBERS/LOCATIONS

| φ | $X_o$ & $X/L_{SILTS}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1568.2 | 1571.5 | 1578.9 | 1590.3 | 1612.1 | 1649.1 | 1666.7 | 1683.2 | 1693.1 |
| | 0.0 | 0.026 | 0.085 | 0.176 | 0.350 | 0.645 | 0.785 | 0.917 | 1.00 |
| 0 | 3601 | | | | | | | | |
| 10 | | 3564 | | 3566 | | | 3570 | 3571 | |
| 20 | | | | | 3567 | 3569 | | | |
| 45 | | 3602 | 3603 | 3604 | 3605 | 3606 | | | |
| 90 | | 3607 | 3608 | 3609 | 3610 | 3611 | | | 3612 |
| 135 | | 3613 | 3614 | 3615 | 3616 | 3617 | | | |
| 180 | | 3618 | 3619 | 3620 | 3621 | 3622 | 3623 | 3624 | |

$L_{SILTS} = 125.4$

* THESE TAPS ARE INCLUDED IN THE VERTICAL TAIL ARRAY ALSO

TABLE VII.   AFT FUSELAGE/OMS POD PRESSURE TAP
NUMBERS/LOCATIONS

| ORB STATION | | $\phi$ ~ RADIAL LOCATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FULL SCALE | $X/L_o$ | 45 | 60 | 70 | 90 | 105 | 110 | 120 | 135 | 150 | 165 |
| 1317.5 | .8390 | | | 291 | 292 | | 218 | 219 | 220 | 221 | 222 |
| 1349.5 | .8638 | | | | | | 223 | 224 | 225 | 226 | 227 |
| 1374.4 | .8831 | | | | | 187 | | 188 | 189 | 190 | 191 |
| 1390.0 | .8951 | | 293 | | | | | | | | |
| 1430.1 | .9262 | 298 | 294 | | | | | | | | |
| 1454.5 | .9451 | | | 295 | 296 | | | | | | |
| 1480.1 | .9650 | 299 | 297 | | | | | | | | |
| 1510.0 | .9881 | 300 | | | | | | | | | |

$$L_o = 1290.3$$

NOTE: THESE LOCATIONS USED FOR DATA REDUCTION — ACTUAL LOCATIONS ARE LISTED ON FIGURE 2g

TABLE VIII.  BAD PRESSURE DATA LIST

(OA400)

| COMPONENT | TEST POINT(S) | PRESSURE TAP NO. | DATASET(S) |
|---|---|---|---|
| Wing Upper Surface | All | 693<br>796 | R3XU60→A5<br>R3XUA1→A5 |
| Wing Lower Surface | All | 900 | R3XL60→A5 |
| Vertical Tail | All | 550 | R3XV50,51 |
| | beta =-8°<br>alpha=-4° | 3533 | R3XVA5 |
| Vertical Tail, Right Side | All | 3518} to be taken<br>3536} from<br>R3XV55→A5 | R3XR55→A5 |
| Inside Speedbrake | All | 3807 | R3XK55,56,95→A5 |
| | | 3812 | R3XK55,56,65 |
| | | 3827 | R3XK70→79,95→A5 |
| Body Flap Top | All | 440 | R3XF55→A5 |
| | beta =4°,8°<br>alpha=12° | 408 | R3XFA3 |
| | beta =4°<br>alpha=12° | 408 | R3XFA4 |
| | beta =8°<br>alpha=16° | 408 | R3XFA5 |
| Aft Fuselage + OMS Pod | All | 297 move from<br>PHI=70° to PHI=60° | R3XB50→A6 |

Notes:

1. Positive directions of force coefficients, moment coefficients, and angles are indicated by arrows

2. For clarity, origins of wind and stability axes have been displaced from the center of gravity
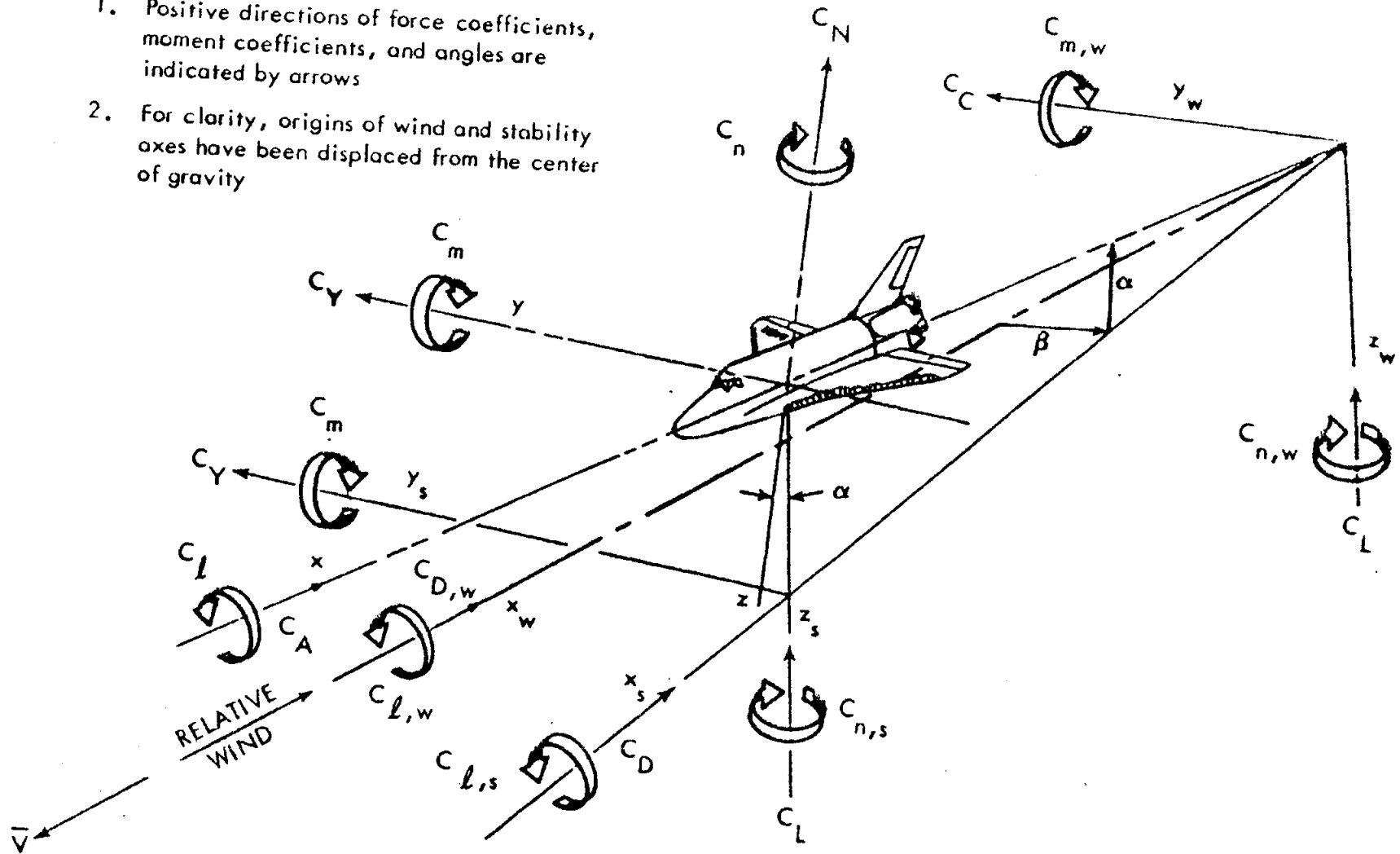
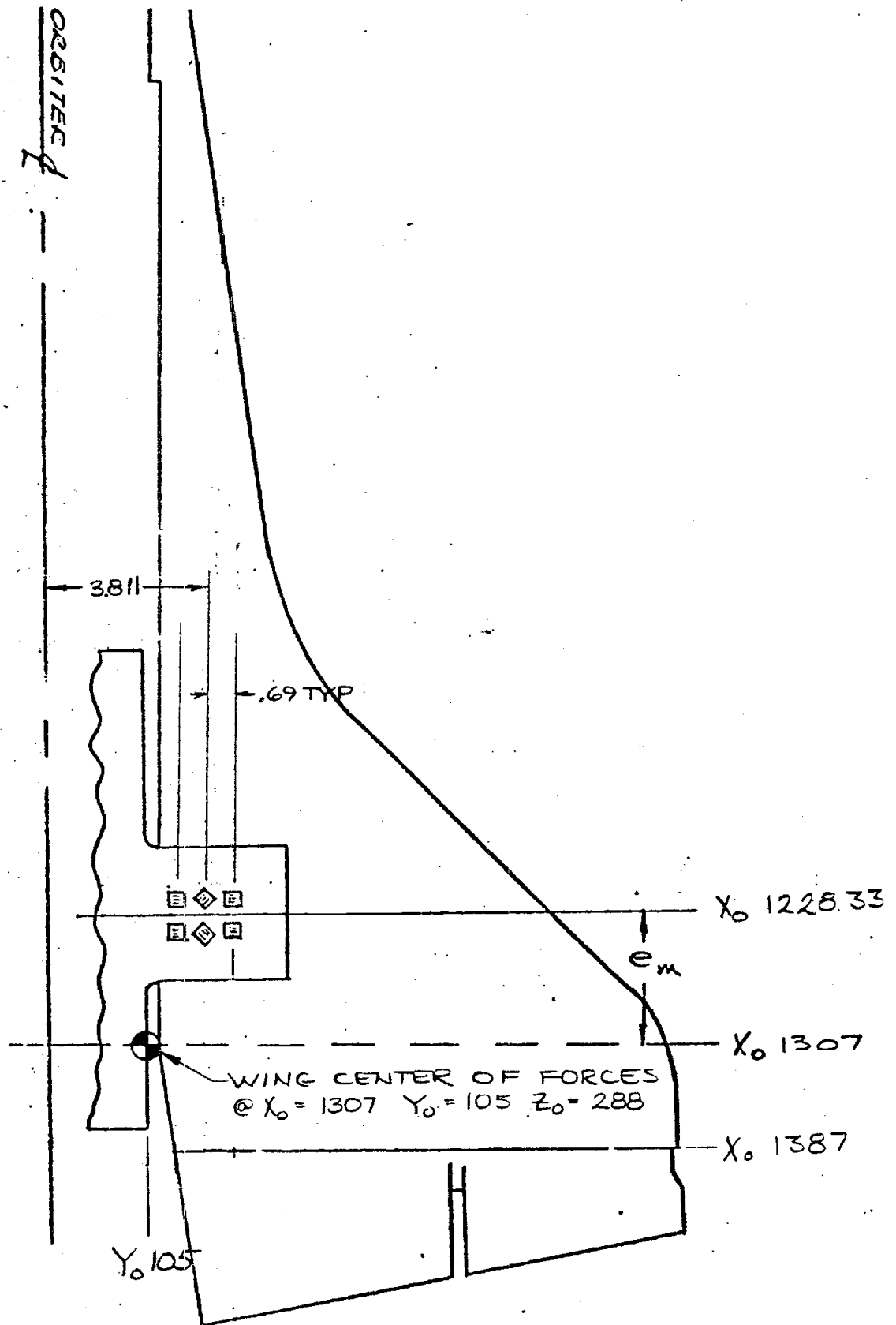a. Orbiter Axis Systems

Figure 1. Axis Systems and Sign Conventions

RUDDER
HINGE LINE

$+CH_{SBR}$

$\delta_{SB} = 87.2^\circ_{MAX}$

$\delta_R = -22.8^\circ$

$+CH_R$   $+CH_{SBL}$

RUDDER AND
SPEEDBRAKE
DEFLECTIONS

ELEVON
HINGE LINE
$X_o$ 1387

$\delta_E = -25^\circ_{MAX.}$

W.R.P.

$\delta_E = +15^\circ_{MAX}$

$+CH_E$

AILERON & ELEVON DEFLECTIONS

$$\delta_a = \frac{\delta_{EL} - \delta_{ER}}{2} \qquad \delta_E = \frac{\delta_{EL} + \delta_{ER}}{2}$$

$\delta_{BF} = -11.7$

$Z_o$ 287

$\delta_{BF} = +22.55$

$+CH_{BF}$

BODY FLAP DEFLECTIONS
$X_o$ 1532

BODY FLAP
HINGELINE
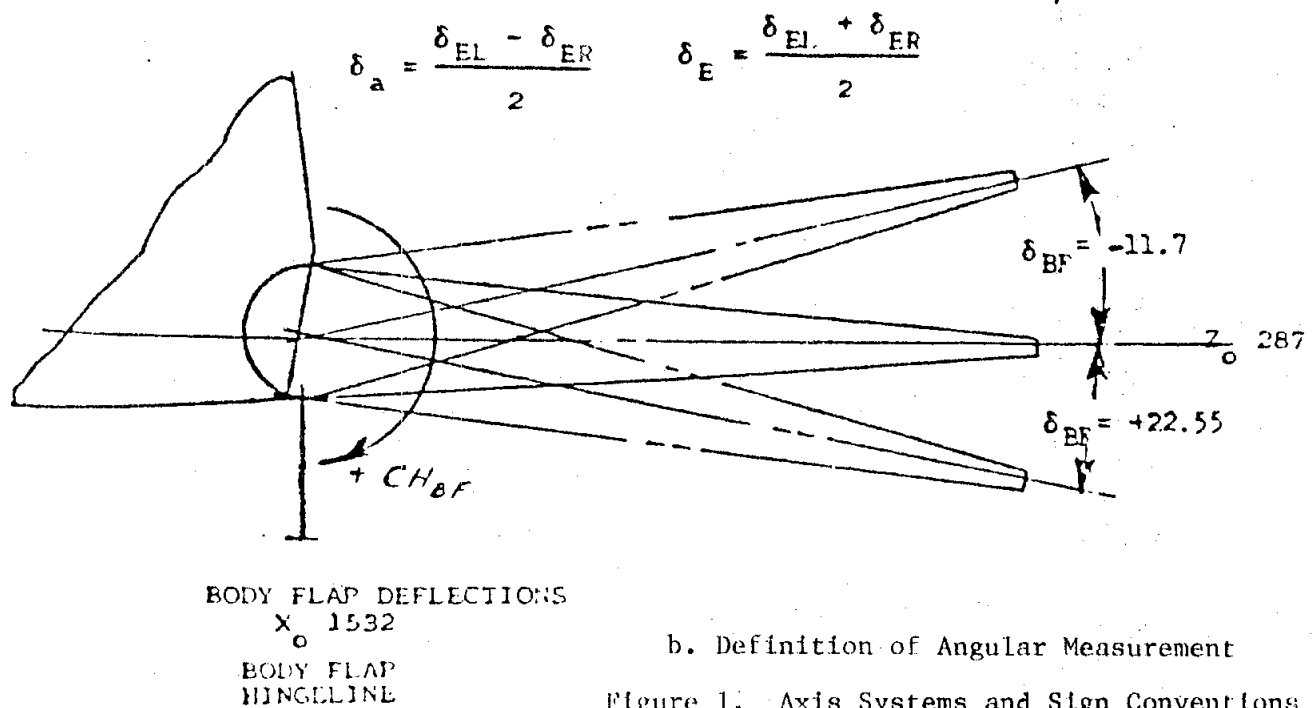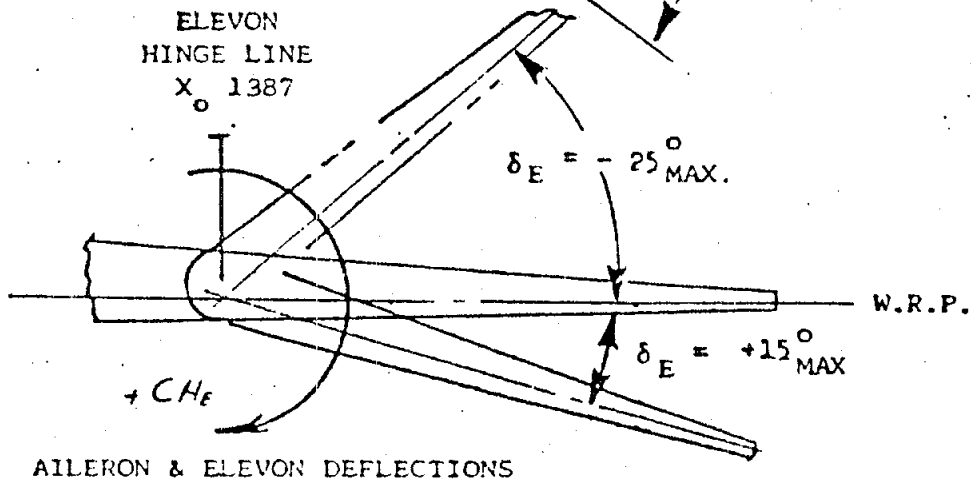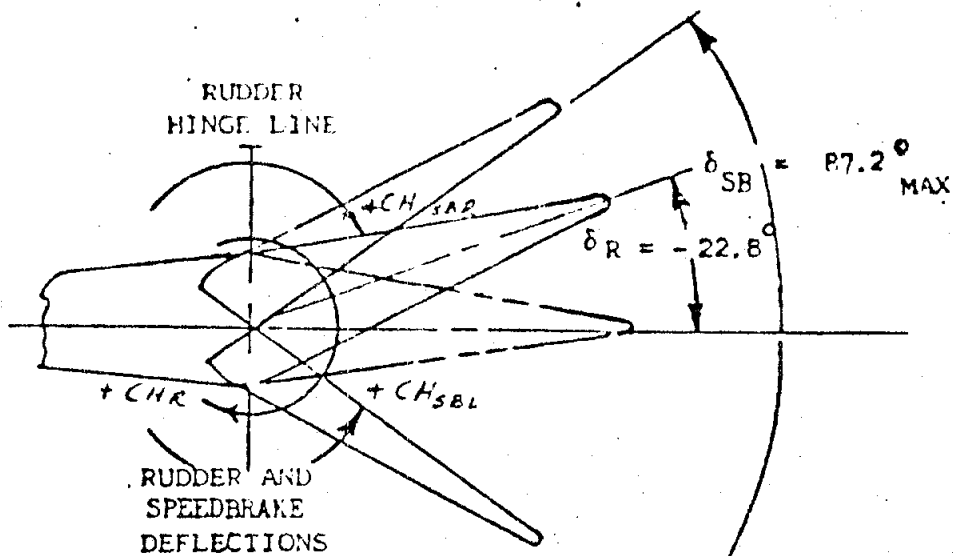
b. Definition of Angular Measurement

Figure 1. Axis Systems and Sign Conventions

39

$X_0$ 30.873

$X_0$ 32.873

$X_0$ 32.301

PIN

BAL. CENTER

$Z_0$ 11.700

$Z_0$ 11.250

0.450

0.572

MRC
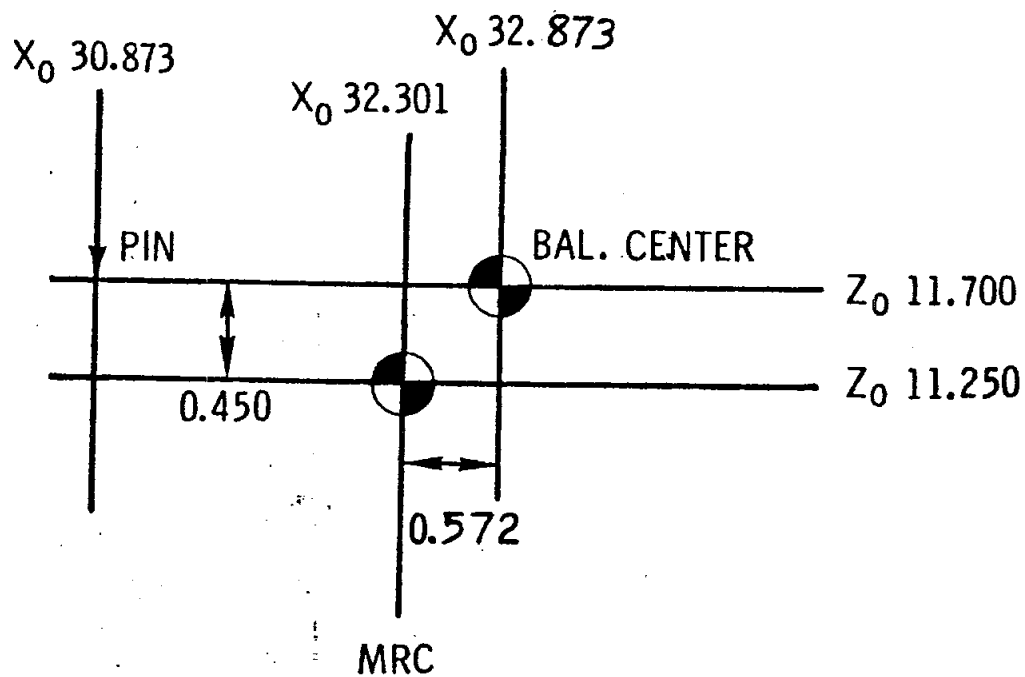
c.   Moment Transfer Diagram – Main Balance

Figure 1.   Axis Systems and Sign Conventions

40

d. Wing Balance Transfer Diagram

Figure 1. Axis Systems and Sign Conventions

41

ELEVONS - $E_{64}$

WING - $W_{131}$

USA

OMS NOZZLES - $N_{28}$

SSME NOZZLES - $N_{112}$

CANOPY - $C_9$

FLIPPER DOORS - $FD_3$

VERTICAL TAIL - $V_8$

RUDDER - $R_5$

FUSELAGE - $B_{62}$

USA

OMS POD - $M_{16}$

UNITED STATES OF AMERICA

BODY FLAP - $F_9$
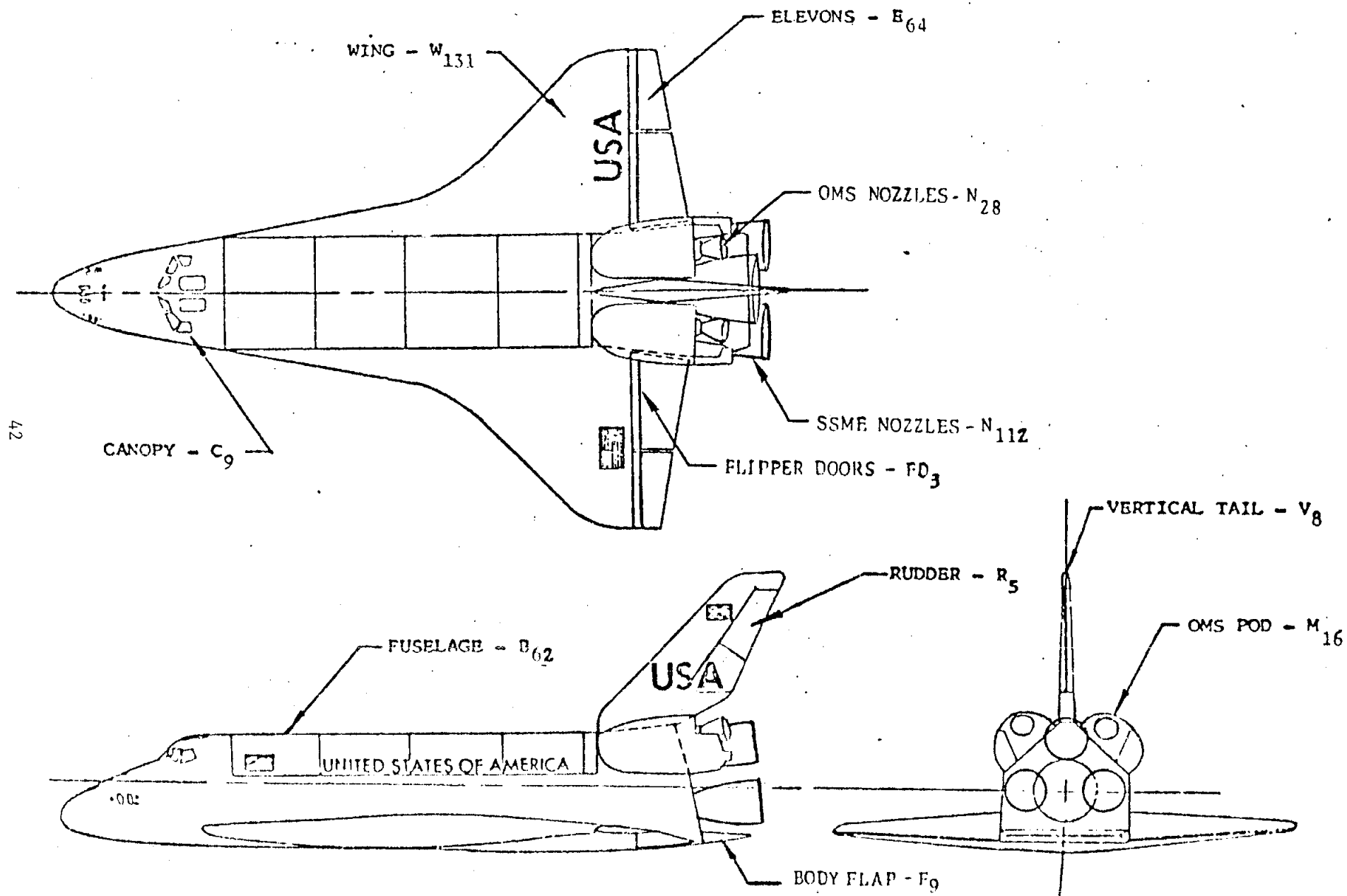
a.  Orbiter Configuration

Figure 2.  Model Sketches

42
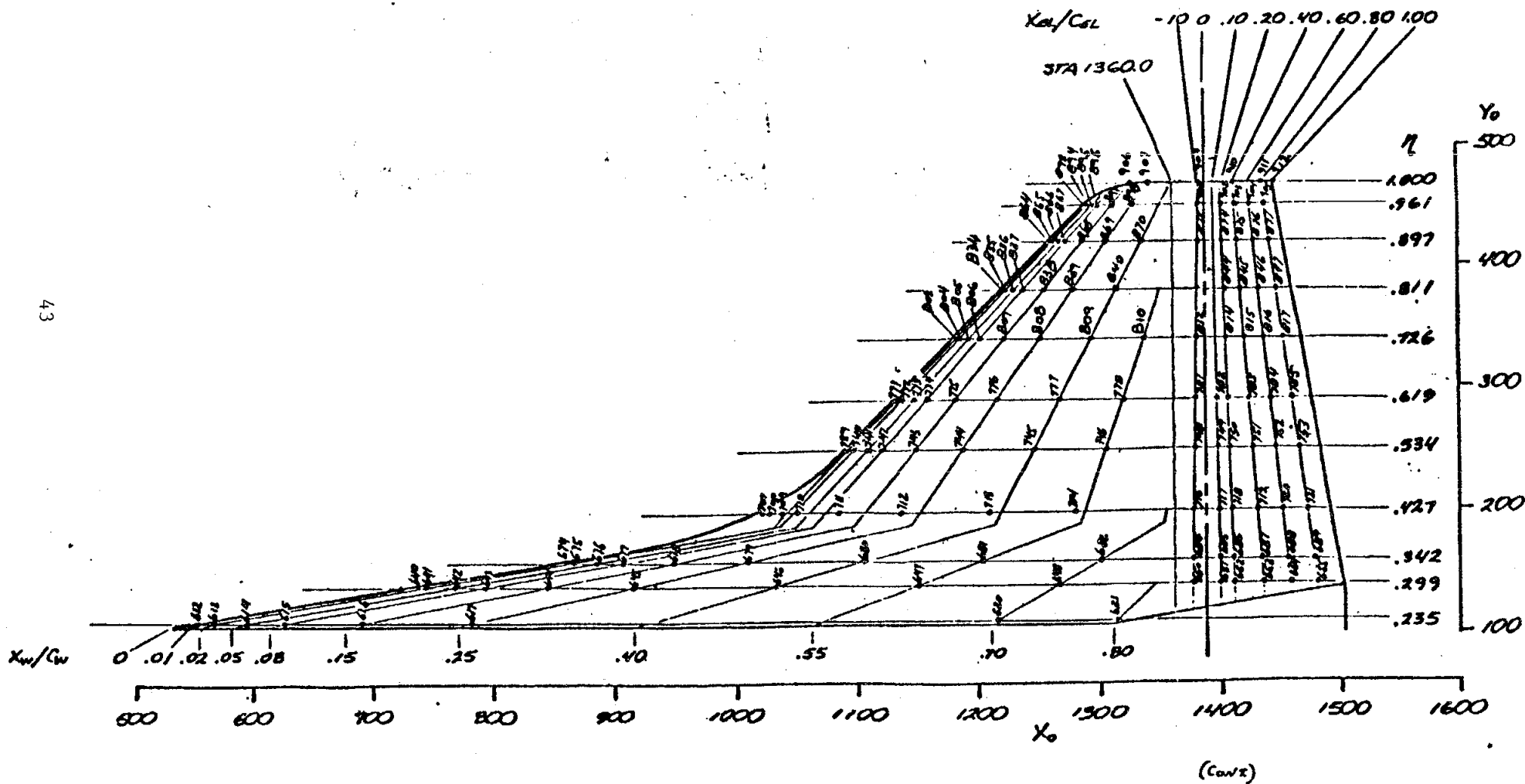
b. Wing Lower Surface Pressure Tap Locations

Figure 2. Model Sketches

43
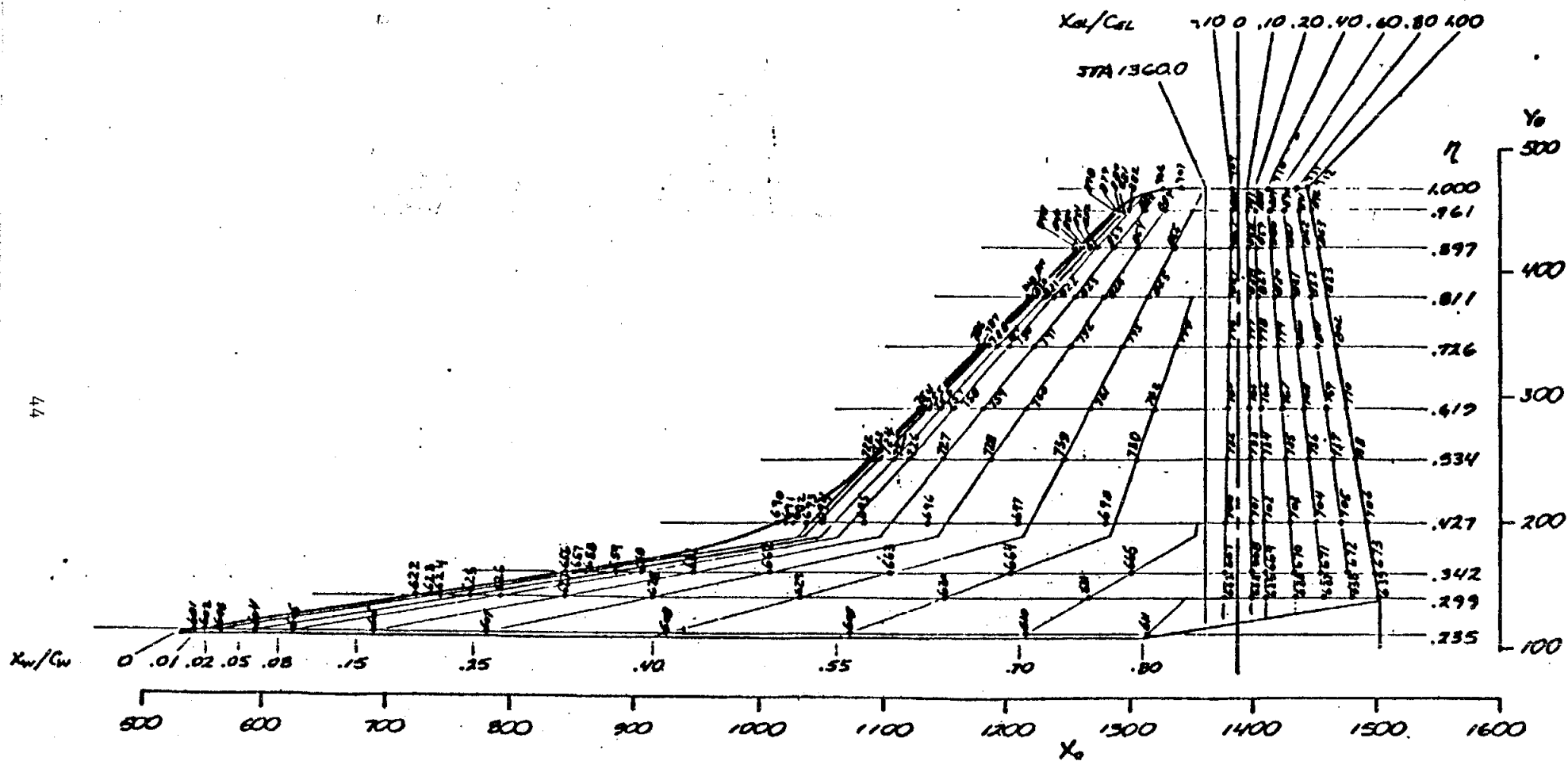
C. Wing Upper Surface Pressure Tap Locations

Figure 2. Model Sketches

| $x/L_{SILTS}$ \ $\phi_{SILTS}$ | 180° | 135° | 90° | 45° | 0° |
|---|---|---|---|---|---|
| .917 | 3624 | | ~ | ~ | |
| .785 | 3623 | | | | |
| .645 | 3622 | 3617 | 3611 | 3606 | |
| .350 | 3621 | 3616 | 3610 | 3605 | |
| .176 | 3620 | 3615 | 3609 | 3604 | |
| .085 | 3619 | 3614 | 3608 | 3603 | |
| .026 | 3618 | 3613 | 3607 | 3602 | |
| .00 | | | | | 3601 |

Note: 3625 & 3626 ARE IN SENSOR CAVITIES ON FRONT OF SILTS

3563 → 3571

3554 → 3562

3545 → 3553

3536 → 3544 LH
3584 → 3590 RH

3527 → 3535

3518 → 3526 LH
3577 → 3583 RH

3509 → 3517

3501
3507

3612
3599
3600
.919
3597
3598
.808
.697
.570
.443
3594 3595 3596 .317
.222
3591 3592 3593

$\eta_v = 0$

0 .03 .06 .15   30   .52   .68   .83   .98 1.00

$X/C_V$
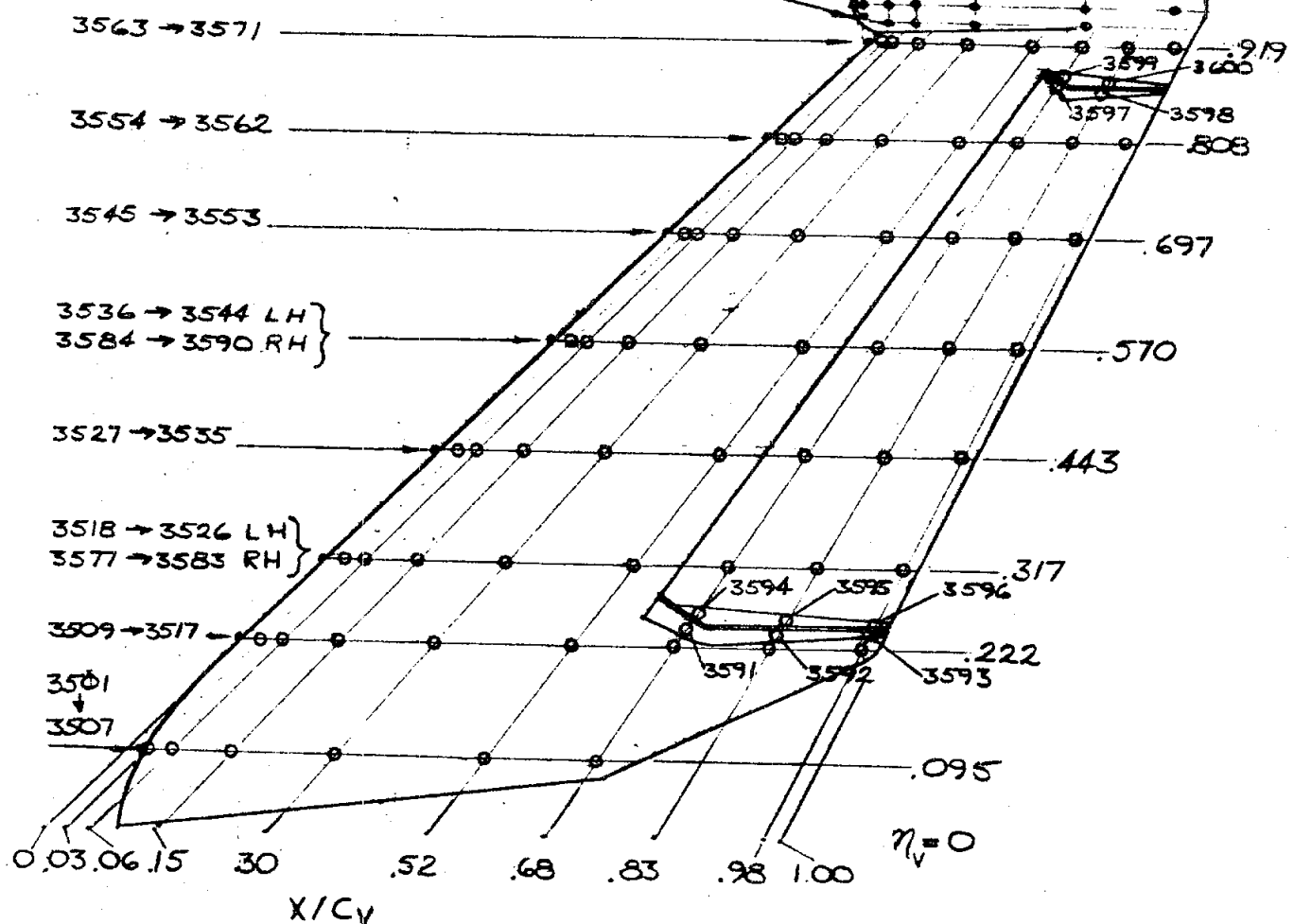
d. SILTS Vertical Tail Pressure Tap Locations

Figure 2. Model Sketches

45

Note: ALL PRESSURE TAPS ARE
ON LEFT-HAND SIDE
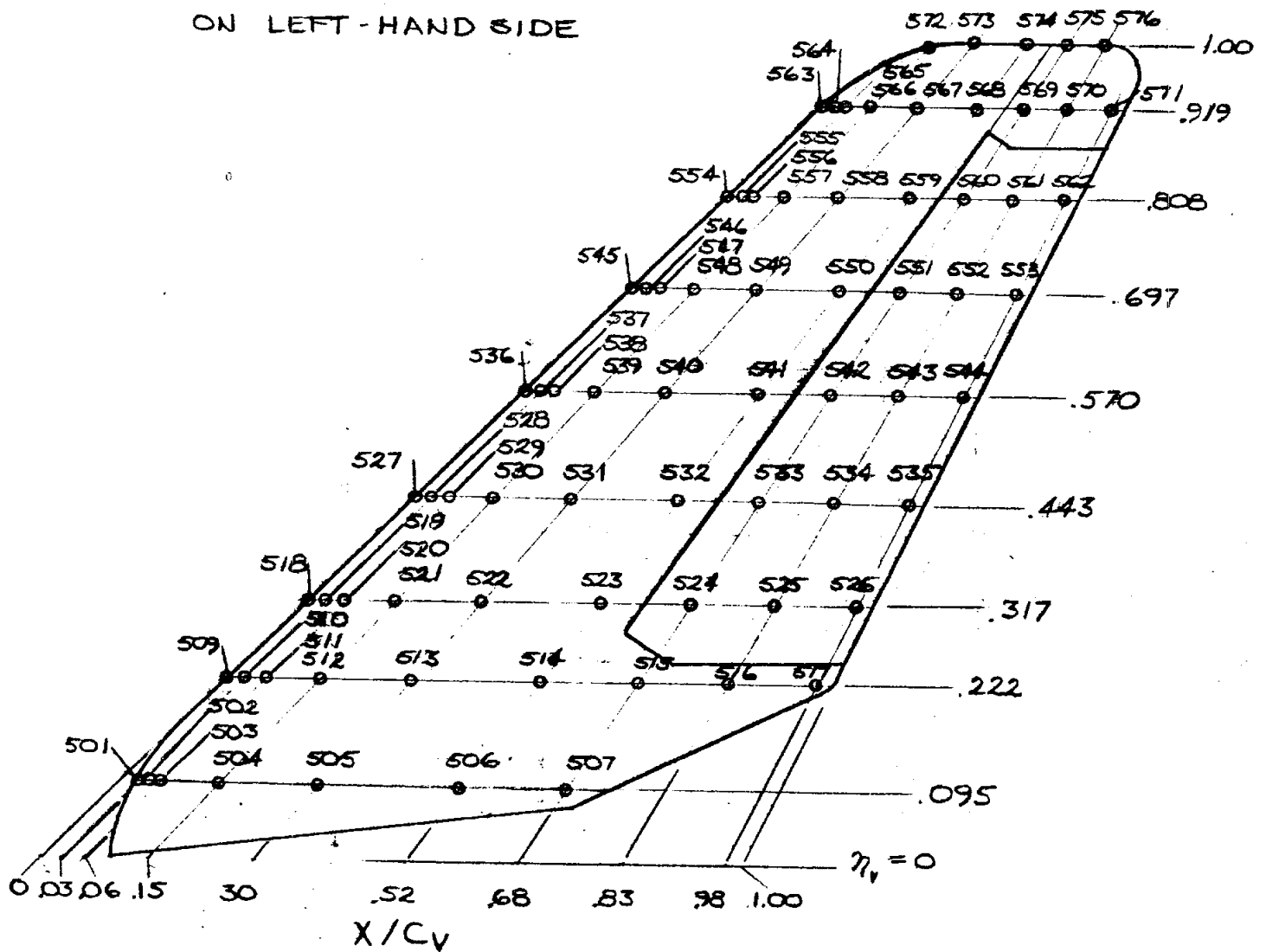
e. Basic Vertical Tail Pressure Tap Locations

Figure 2. Model Sketches

46

Note: THESE NUMBERS ARE
FOR THE VERTICAL W/O
SILTS. FOR SILTS ON
CHANGE FIRST DIGIT
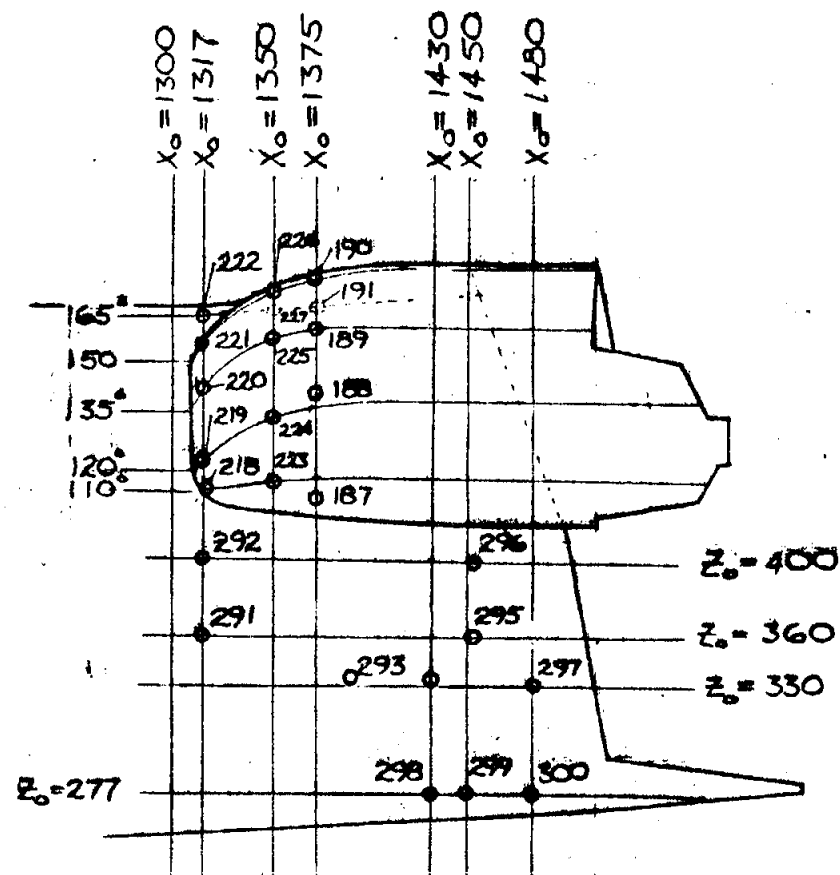TO "3". ALL LOCATIONS
ARE THE SAME.

0.10

4

0.65  0.90

0.40

0.25

1826  1827 1828  1829  1830 ___ WL 22.50

1821 ___ 1822 1823  1824  1825 ___ WL 21.60

1816 ___ 1817 1818  1819  1820 ___ WL 20.70

1811 ___ 1812 1813  1814  1815 ___ WL 19.80

1806 ___ 1807 1808  1809  1810 ___ WL 18.90

1801 ___ 1802 1803  1804  1805 ___ WL 18.00

TOTAL  30

X
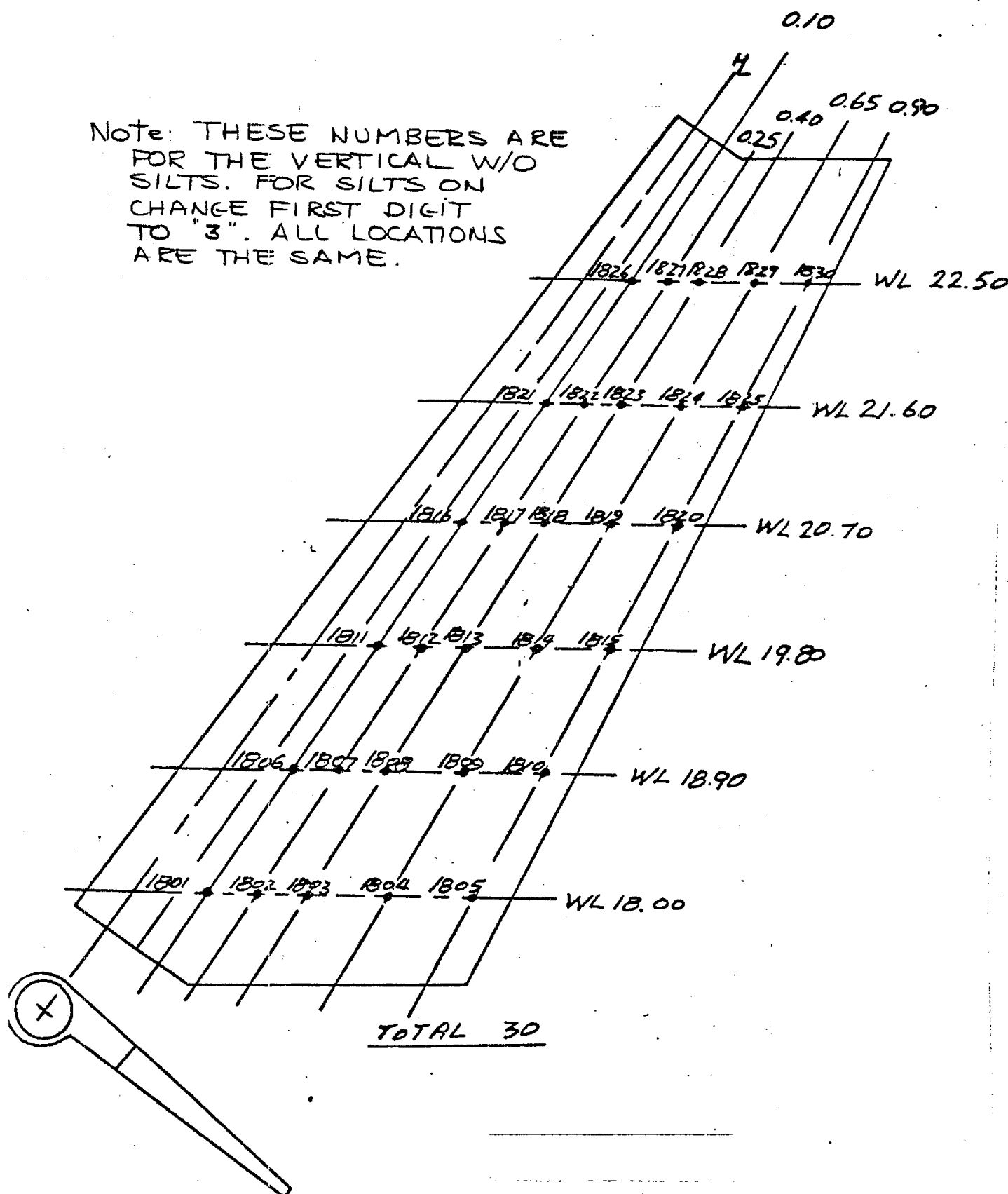
f.   Inside Speedbrake Pressure Tap Locations

Figure 2.   Model Sketches

| TAP No. | $\phi_o$ | $X_o$ | $Y_o$ | $Z_o$ |
|---|---|---|---|---|
| 187 | 106.0 | 1374.4 | -127.9 | 436.6 |
| 188 | 128.8 | 1374.4 | -133.8 | 479.7 |
| 189 | 135.2 | 1375.5 | -108.5 | 509.1 |
| 190 | 150.3 | 1374.9 | -74.2 | 530.3 |
| 191 | 165.4 | 1374.5 | -27.8 | 506.3 |
| 218 | 110.6 | 1317.5 | -112.3 | 442.3 |
| 219 | 120.3 | 1317.6 | -110.5 | 464.4 |
| 220 | 135.0 | 1317.8 | -88.9 | 488.7 |
| 221 | 150.0 | 1317.8 | -60.0 | 503.7 |
| 222 | 164.8 | 1318.9 | -27.1 | 499.6 |
| 223 | 110.3 | 1349.7 | -129.6 | 448.0 |
| 224 | 120.3 | 1349.3 | -127.9 | 474.6 |
| 225 | 135.1 | 1349.6 | -103.5 | 503.7 |
| 226 | 149.8 | 1350.0 | -72.1 | 523.7 |
| 227 | 164.9 | 1349.5 | -27.9 | 503.2 |
| 291 | 71.1 | 1317.5 | -106.6 | 363.5 |
| 292 | 91.1 | 1317.5 | -106.8 | 402.0 |
| 293 | 59.9 | 1390.0 | -113.4 | 334.3 |
| 294 | 60.9 | 1430.2 | -117.5 | 334.6 |
| 295 | 71.6 | 1454.5 | -118.9 | 360.5 |
| 296 | 91.3 | 1454.5 | -117.0 | 402.6 |
| 297 | 61.3 | 1480.1 | -122.7 | 332.9 |
| 298 | 44.3 | 1430.0 | -120.0 | 277 |
| 299 | 45.7 | 1450.0 | -126.0 | 277 |
| 300 | 46.5 | 1480.0 | -129.5 | 277 |

8. Aft Fuselage/OMS Pod Pressure Tap Locations

Figure 2. Model Sketches

48

| TAPNo | $Z_o$ | $Y_o$ |
|-------|-------|-------|
| 301 | 532 | 0 |
| 303 | 478 | 0 |
| 304 | 405 | 55 |
| 306 | 340 | 0 |
| 307 | 302 | 0 |
| 308 | 478 | -38 |
| 309 | 439 | -38 |
| 310 | 405 | -55 |
| 311 | 302 | -78 |
| 312 | 439 | -78 |
| 313 | 410 | -78 |

| TAPNo | $Z_o$ | $Y_o$ |
|-------|-------|-------|
| 314 | 302 | -78 |
| 315 | 414 | -103 |
| 316 | 376 | -103 |
| 317 | 340 | -103 |
| 318 | 302 | -103 |
| 319 | 514 | -55 |
| 320 | 492 | -88 |
| 321 | 522 | -96 |
| 322 | 470 | -96 |
| 323 | 439 | -107 |
| 324 | 465 | -130 |

h. Base Pressure Tap Locations

Figure 2. Model Sketches

49

## UPPER SURFACE

$X/C_{BF}$

-.10

H.L.

.20

.60

.95

437    429    421    413    405

438    430    422    414    406

439    431    423    415    407

440    432    424    416    408

$\eta = .90 \quad .80 \quad .65 \quad .50 \quad .10$
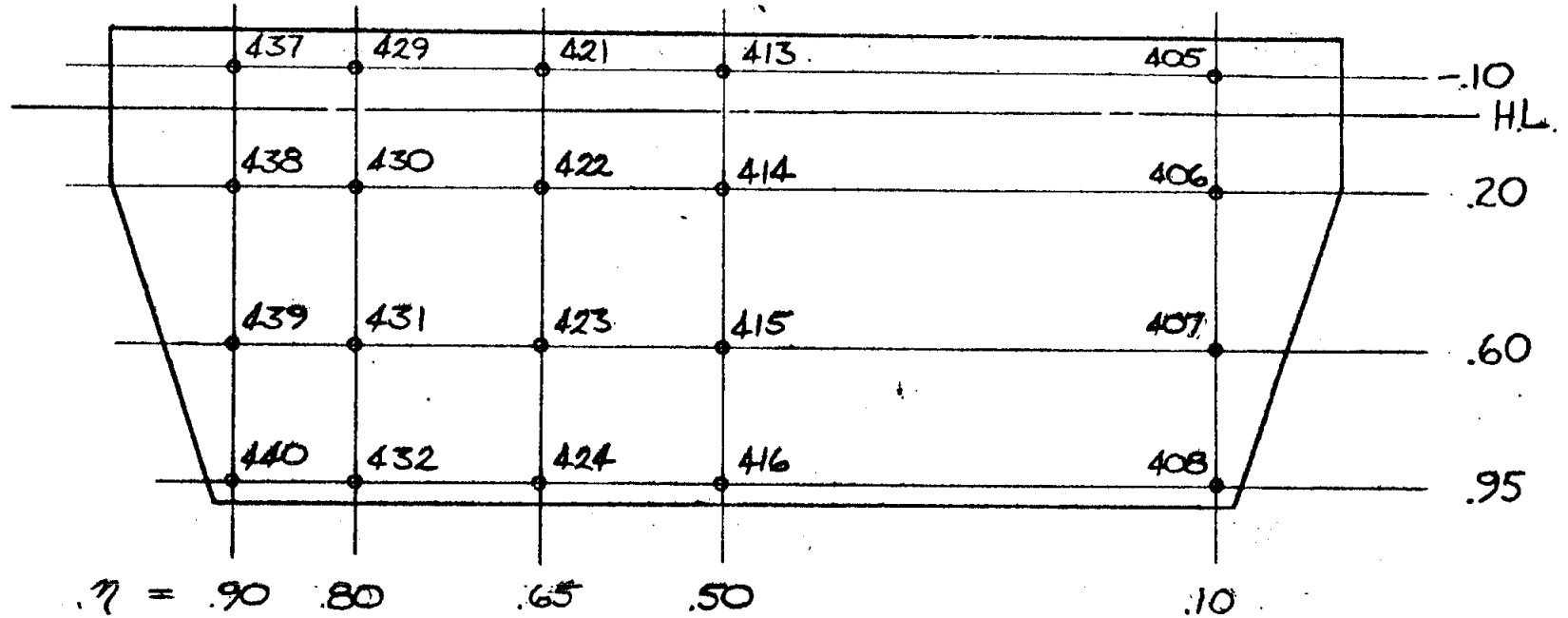
| $\eta$ | $X/C_{BF}$ | | | |
|------|------|------|------|------|
|      | -.10 | .20  | .60  | .95  |
| .10  | 405  | 406  | 407  | 408  |
| .50  | 413  | 414  | 415  | 416  |
| .65  | 421  | 422  | 423  | 424  |
| .80  | 429  | 430  | 431  | 432  |
| .90  | 437  | 438  | 439  | 440  |

i.    Body Flap Pressure Tap Locations

Figure 2.    Model Sketches

50

BALL BEARING

SECTION $Y_0$ = 6.30

LEAD CHANNEL

SQUARE KEY

$\delta_e$ BRACKETS

ELEVON HINGE
MOMENT BEAM
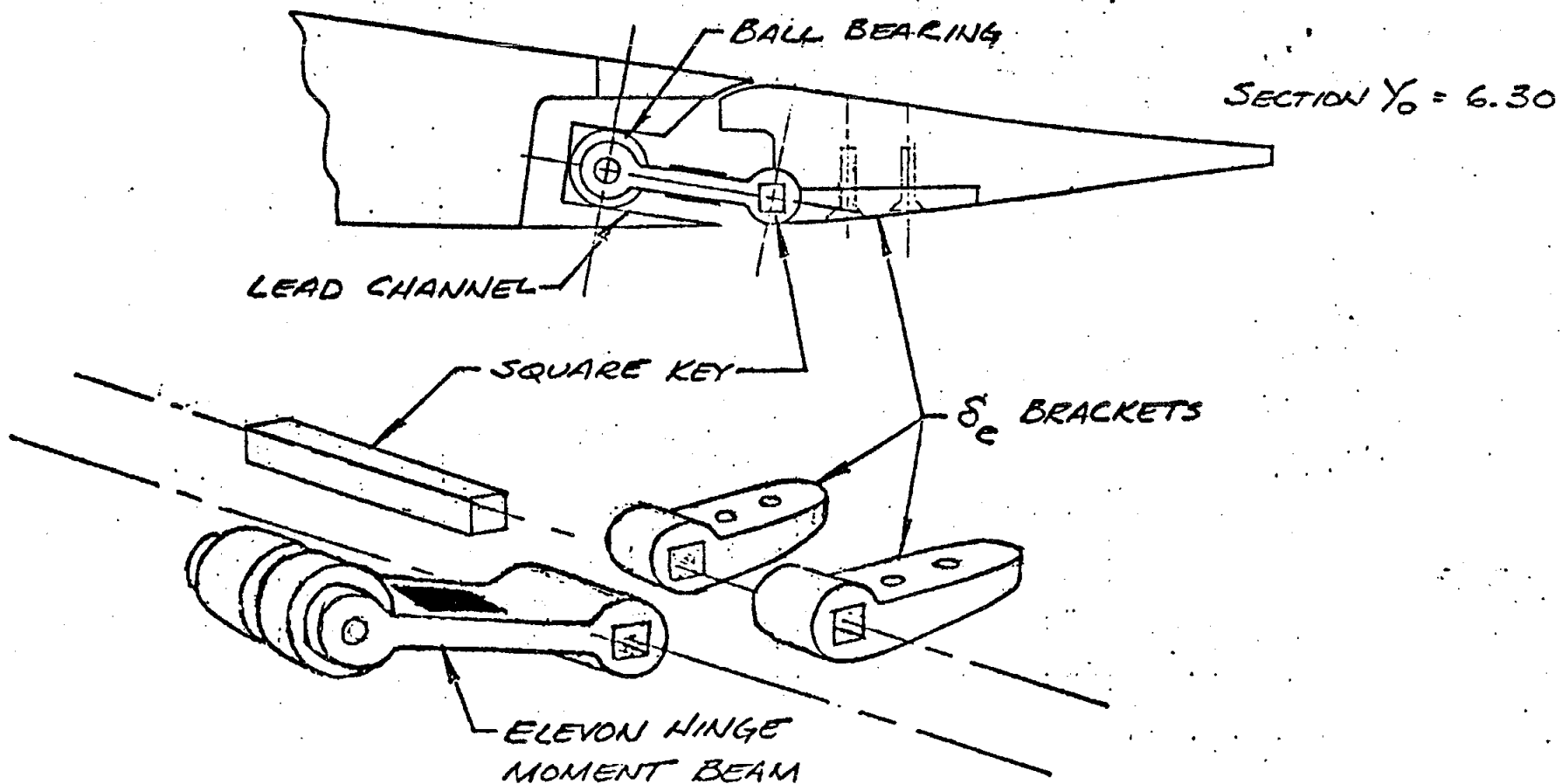
j.   Elevon Hinge Moment Beam Details

Figure 2.   Model Sketches

51

.020

765

.45

SPAR

$P_M$

$MV1$

$MV3$

$MV2$

$X'$

32.689°

$X_o = 1401.33$

$Z_o = 500$
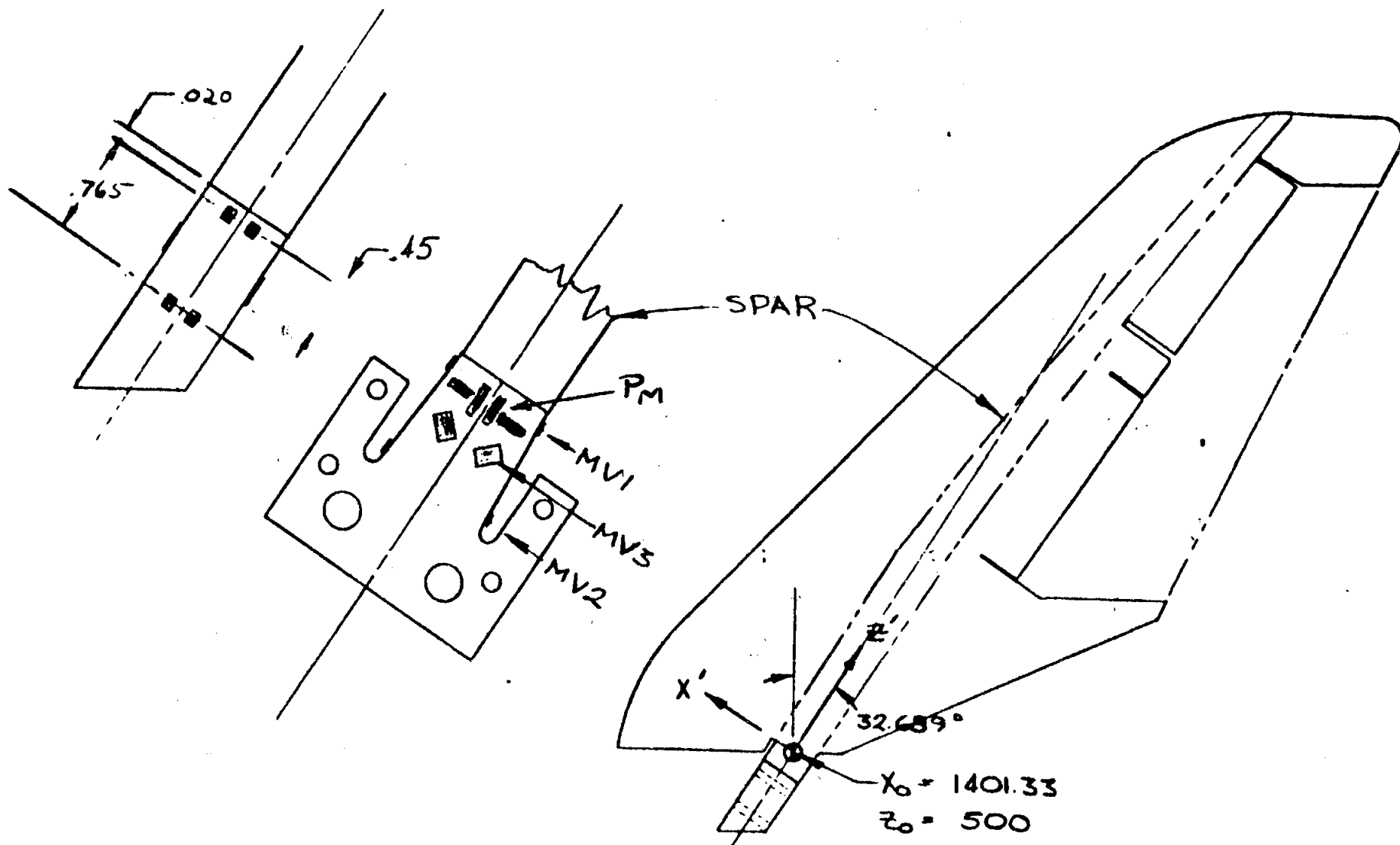
k.   Flexible Vertical Tail Details

Figure 2.   Model Sketches

ROCKWELL W11095 STING

AMES 29.0 STING

$10°$ PRIMARY TAPER
ADAPTER

$\alpha = 20°$

TUNNEL $\not{L}$ $\alpha = 0°$

$X_0$ $\overline{32.873}$
2.5 IN. MK XX BALANCE CENTER
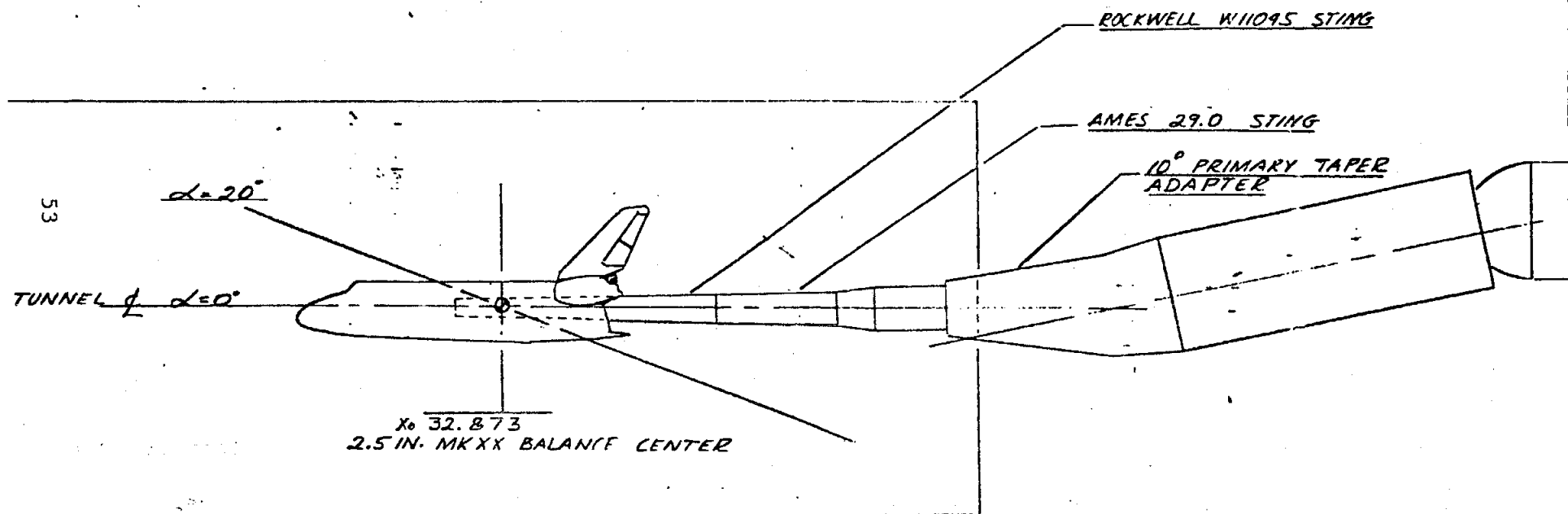
1. Model 47-0 in the NASA/ARC 11X11-FT. TUNNEL

Figure 2.   Model Sketches
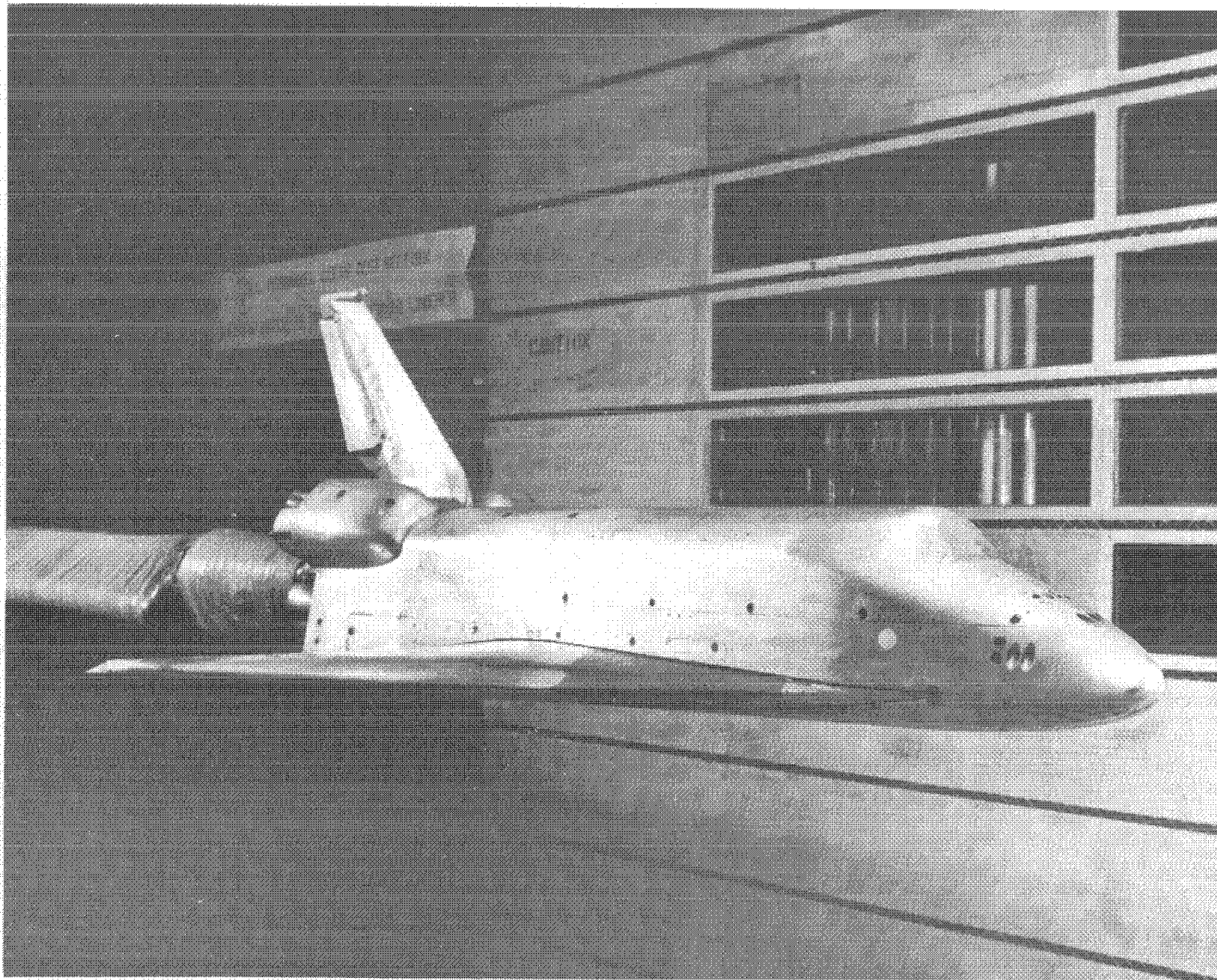
a. Three-Quarter Front View of Model 47-0 in the
NASA/ARC 11x11-ft. Wind Tunnel

Figure 3. Model Photographs
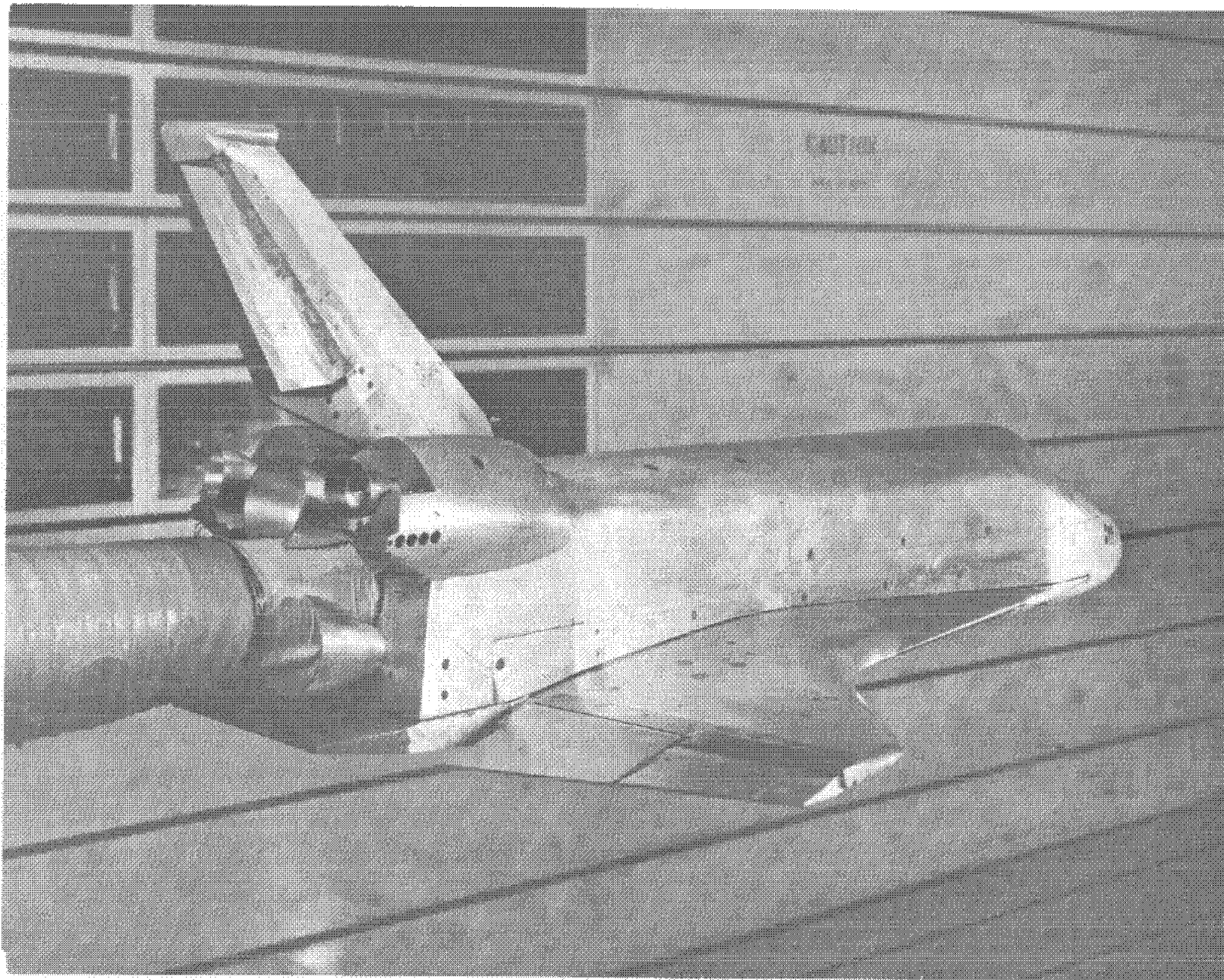
b. Three-Quarter Rear View of Model 47-0 in the NASA/ARC 11x11-ft. Wind Tunnel

Figure 3. Model Photographs
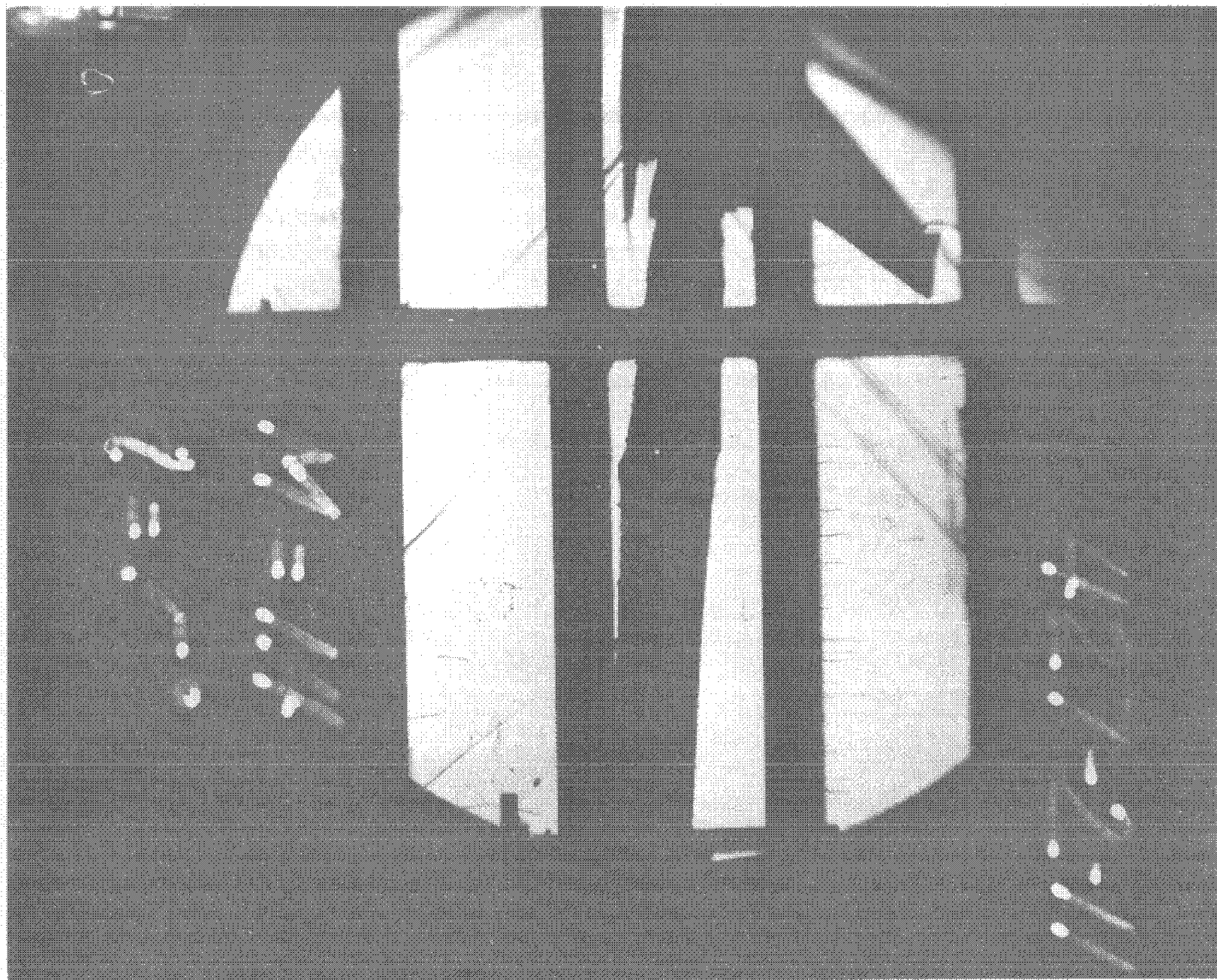
c. Schlieren Picture of SILTS Vertical Tail at M = 1.4, α = 5°

Figure 3. Model Photographs

DATA FIGURES

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APPENDIX

TABULATED SOURCE DATA

Tabulations of plotted data are available on request from Data Management
Services.

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